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Satellite Power Systems (SPS) Concept Definition Study (Exhibit D)

Volume VI, Part 2 - Cost and Programmatic Appendix

G. M. Hanley

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**Satellite Power Systems (SPS) Concept
Definition Study (Exhibit D)**

Volume VI, Part 2 - Cost and Programmatic Appendix

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Prepared for
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FOREWORD

Volume VI, SPS Cost and Programmatic—Appendixes, is a supporting document of Volume VI and contains the SPS WBS and dictionary, plus a presentation of cost estimates on the SPS program. This volume is submitted by Rockwell International through the Space Operations and Satellite Systems Division and reports on the work completed through October 1980. All reports are responsive to the NASA/MSFC Contract NAS8-32475, Exhibit D and Amendment 1, dated June 18, 1979.

The SPS final report provides the NASA with additional information on the selection of a viable SPS concept, and furnishes a basis for subsequent technology advancement and verification activities. Volumes of the final report are listed as follows:

Volume

- | | |
|-----|---|
| I | Executive Summary |
| II | Systems/Subsystems Analyses |
| III | Transportation Analyses |
| IV | Operations Analyses |
| V | Systems Engineering/Integration Research and Technology |
| VI | Cost and Programmatic |
| | <div style="border: 1px solid black; padding: 2px; display: inline-block;">Cost and Programmatic—Appendixes</div> |
| VII | Systems/Subsystems Requirements Data Book |

The SPS Program Manager, G. M. Hanley, may be contacted on any technical or management aspects of this report. He can be reached at (213) 594-3911, Seal Beach, California.

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ACKNOWLEDGEMENTS

For the past five years, Rockwell International has worked on concept definitions and cost/programmatics of a Satellite Power System (SPS) involving both ground and space segments. This included a study of technology advancements, the analysis of cost/economic factors, an examination of resource requirements, and the documentation of end-to-end sequences in terms of integrated schedules and preliminary program plans covering DDT&E, acquisition, and operational phases of the SPS program. The results of this work are documented in this final report, and represent the professional contribution of many individuals, where most of them have been with the SPS program since the beginning. It is this contribution that needs acknowledgement.

Studies of SPS program development, technology advancement, and system integration were completed under the direction of F. W. Von Flue with support from a staff of competent individuals who researched and analyzed technical parameters for the development of study conclusions. The members of this SPS team include:

- | | |
|-------------------|---------------------------------|
| • Dr. L. R. Blue | Cost/Risk Computer Programming |
| • H. H. Chu | Computer Program Cost Data Base |
| • P. R. Fagan | Technology Development |
| • H. E. Froehlich | Schedule Analysis |

The help and support of personnel from NASA/MSFC and the SPS Program Planning Office are also acknowledged.

- Engineering Cost Group
 - W. S. Rutledge
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- Program Plans and Requirements Group
 - W. A. Ferguson
 - H. K. Turner

APPENDIX A
SATELLITE POWER SYSTEM WORK BREAKDOWN
STRUCTURE DICTIONARY

SOLAR PHOTOVOLTAIC CELLS
CONCENTRATION RATIO (CR)—2 EFF.
THREE-TROUGH PLANAR
END-MOUNTED ANTENNA(S)

APPENDIX A

SATELLITE POWER SYSTEM WORK BREAKDOWN STRUCTURE DICTIONARY

INTRODUCTION

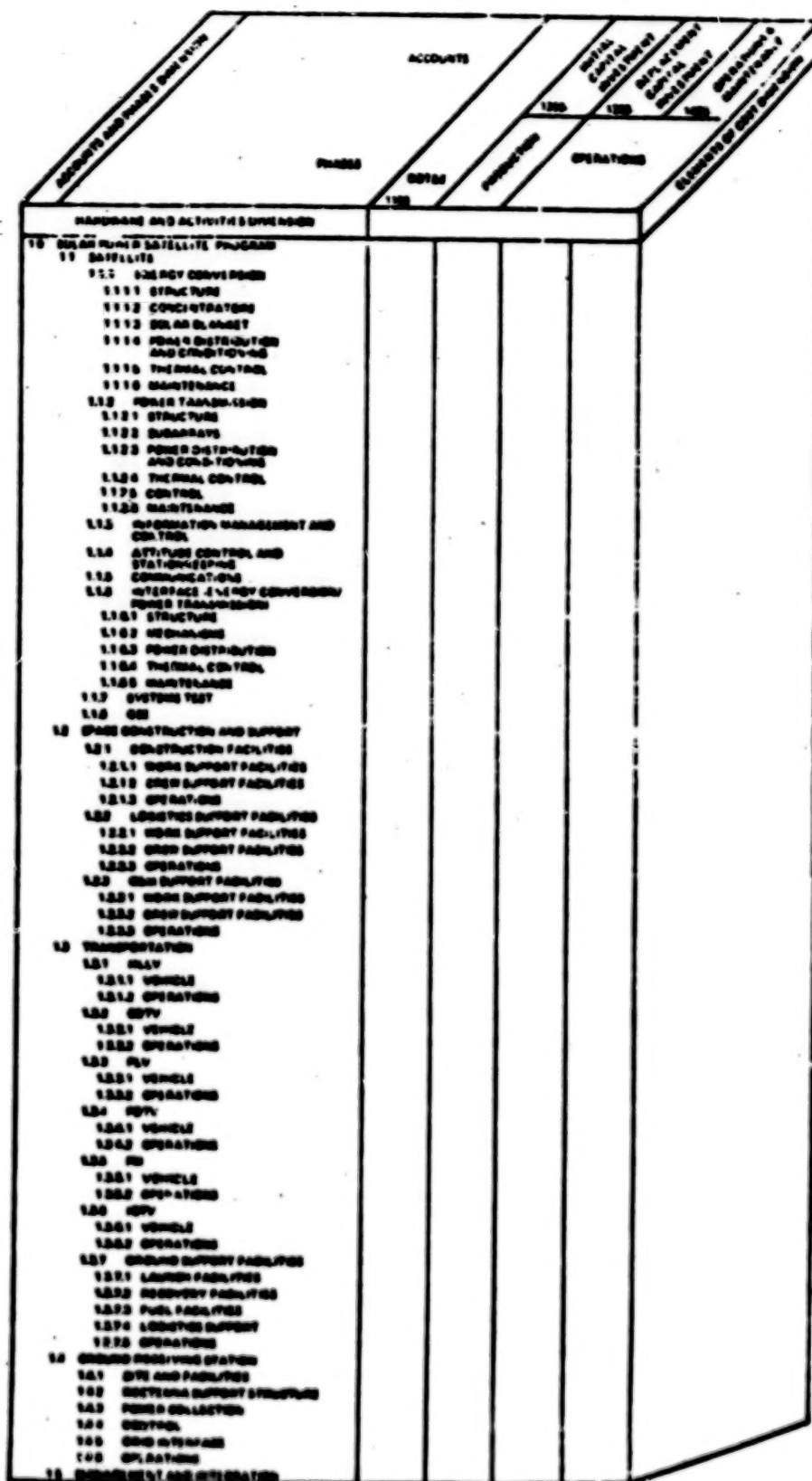
Generally a work breakdown structure (WBS) is a product-oriented family tree composed of all hardware, software, services, and other tasks necessary to define the program. It offers visual display, relates project elements, and defines the work to be accomplished. The WBS is then a tool that will facilitate communications and foster understanding of a complex program by dividing this program into less complex, more manageable subdivisions or elements. It is most desirable that this same WBS provide a uniform basis for management and control, cost estimating, budgeting and reporting, scheduling activities, organizational structuring, specification tree generation, weight allocation and control, procurement and contracting activities, and serve as a tool for program evaluation. On this basis, the WBS developed and defined herein is primarily tailored to the unique cost, economic, and programmatic requirements of the Satellite Power System (SPS). It is designed to allow a standard and logical format for estimating SPS project cost while, at the same time, permitting cost and economic comparisons of SPS to alternate and competitive candidates for producing power.

WBS MATRIX

The total WBS matrix shown in Figure A-1 is a three-dimensional structure that shows the interrelationship of (1) the hardware and activities dimension, (2) the accounts and phases dimension, and (3) the elements of cost dimension. This latter dimension is not further developed at this time, but is provided to show the overall expansion capability built into the WBS matrix. This dimension will become more important in later years when the SPS program approaches a Phase C/D start and is defined to the extent that the elements of cost can be planned and estimated with realism.

There is, of course, the fourth dimension of time which cannot be graphically shown but must be considered also. Each entry on the other three dimensions varies with time, and it is necessary to know these cost values by year for budget planning and approval, and to establish cost streams for discounting purposes.

While a multi-dimensional approach may at first appear unduly complex, it actually provides benefits that far outweigh any such concern. This structural interrelationship provides the capability to view and analyze the SPS from a number of different financial and management aspects. Costs may be summed by hardware groupings, phases, functions, etc. The WBS may be used in a number of three-dimensional, two dimensional, or single-listing format applications.



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ACCOUNTS AND PHASES DIMENSION

The accounts and phases dimension differs somewhat from the typical breakout for government aerospace programs in that it has been developed to also accommodate the financial involvement of the private sector, hence, the inclusion of the breakout of financial divisions or "accounts." Distinctions have been made between capital expenditures, which are recoverable by annual depreciation charges and are not deductible as expenses, and operation and maintenance charges against income, which are deductible as expenses in the year incurred.

To accomplish this objective, four financial accounts have been established. Design, development, test, and evaluation (DDT&E) includes the one-time costs associated with the development of components, subsystems, and systems required for the SPS project. Initial capital investment includes the costs associated with initial procurement and emplacement of the SPS plant and equipment. Replacement capital investment includes the costs associated with capital asset replacements over the operating life of the SPS (e.g., subsystem spare parts, overhauls, etc.). Operations and maintenance (O&M) includes the costs of expendables (e.g., propellants for the propulsion subsystem thrusters), minor maintenance, repair crews, etc. The interrelationship of the financial accounts to the normal aerospace program phases of DDT&E, investment, and operations are also shown in this dimension of the WBS matrix to permit traceability to these more commonly recognized terms.

HARDWARE AND ACTIVITIES WBS DIMENSION

The hardware and activities WBS dimension contains hardware elements of the satellite system and ground system subdivided into subsystems and assemblies. Inherent within this dimension is the capability for further subdivision to lower levels of detail limited only by the realism of the requirements.

Required support hardware, possibly developed under the sponsorship of other programs, is also displayed here for completeness and includes such items as space construction and support equipment and transportation vehicles. Some or all of these support elements may be developed for multiple project applications. A determination will be made later as to how much, if any, of the development costs of these support elements should be charged against the SPS program.

Each of the elements of support hardware is broken out only at a summary level within the SPS WBS. However, they each have their own detailed WBS which could be displayed in depth under the SPS WBS if required.

Finally, the hardware and activities WBS dimension also includes the necessary activities of management, integration, operations, etc., required to accomplish the overall SPS missions.

DICTIONARY ORGANIZATION

The SPS dictionary is divided into:

- (1) A graphic display of the three-dimensional WBS matrix (Figure A-1)
- (2) The definitions of terms of the accounts and phases dimension (pages A-5 and A-6)
- (3) The definitions of terms of the WBS hardware and activities dimension (pages A-7 through A-16)

A systematic numerical coding system coordinates the rows of the hardware and activities dimension to the columns of the accounts and phases dimension such that all matrix locations are identifiable by WBS number.

Since each matrix position corresponds to one particular row of the hardware and activities dimension and also to one particular column of the accounts and phases dimension, a complete definition of any matrix position is constructed by combining the definitions from the two applicable dimensions. That is, to avoid repetition, definitions are provided only once for each hardware and activities dimension row and only once for each accounts and phases dimension column, and a complete definition for any matrix position is a combination of these two definitions.

DEFINITIONS OF ACCOUNTS AND PHASES

1100—DESIGN, DEVELOPMENT, TEST, AND EVALUATION (DDT&E)

The DDT&E account/phase consists of the one-time costs associated with designing, developing, testing, and evaluating the components, subsystems, and systems required for the SPS project. It includes the development engineering, testing, and support necessary to translate a performance specification into a design. It encompasses the preparation of detailed drawings for system hardware fabrication, system integration, and (depending on the system, subsystem, or component) structural, environmental, and other required tests. It includes all ground tests, sortie tests, subscale and full-scale SPS tests, and all hardware fabrication required for such tests. Also included are the analysis of data and whatever redesign and retest activities are necessary to meet specifications. It also includes ground support equipment, special test equipment, and other program-peculiar costs not associated with repetitive production. All SPS related support systems such as transportation, space construction base, and assembly/support equipment necessary to accomplish the DDT&E phase are included at present for completeness. It may later be determined that some of these support systems will exist with or without SPS; therefore, they may not be chargeable to the SPS project.

1200—INITIAL CAPITAL INVESTMENT

The initial capital investment account is a summation of those plant and equipment expenditures made for the initial procurement and installation of each full-scale SPS. That is, this account collects the production, assembly, installation, transportation, test, etc., costs of each individual satellite and ground station that is associated with, and necessary to, bringing the power plant on-line (in government aerospace terminology, this corresponds to costs in the investment phase). Examples of costs collected in this account are the procurement cost and launch cost of the satellite system itself, the procurement cost of the ground system (including installation), and all other necessary costs to achieve this end such as those attributable to space stations, launch vehicle fleets, etc. Also included is pro rata share of such functional costs as program management, SE&I, etc., related to the foregoing systems. Only costs incurred after the end of the DDT&E phase and prior to the initial operational capability (IOC) of each SPS are collected in this account.

1300—REPLACEMENT CAPITAL INVESTMENT

The replacement capital investment account is a summation of those plant and equipment expenditures made for capital asset replacement and major overhauls that are expected to last more than one year and result in an improvement to the operating system. Examples of costs collected in this account are the costs of spares, their installation and associated launch costs or ground transportation costs, permanent improvements in the system such as rotary joint replacement, installation of improved design satellite control equipment, etc.,

as well as pro rata shares of functional costs. Replacement capital investment expenditures are grouped into two categories in order to identify those costs and activities that occur before or after initial operational capability (IOC) of the SPS.

1400—OPERATIONS AND MAINTENANCE (O&M)

The O&M account is a summation of those expenditures incurred in the day-to-day operations beginning with the IOC and continuing over the life of each SPS. Examples of costs collected in this account are wages of operations and maintenance personnel, minor repairs and adjustments to systems to maintain an ordinarily efficient operating condition, expendables and consumables, launch costs for transfer of on-orbit personnel and resupply of expendables and consumables, etc.

DEFINITIONS OF HARDWARE AND ACTIVITIES

1.0 SATELLITE POWER SYSTEM PROGRAM

The program includes all the elements of hardware, software, and activities required for the design, development, production, assembly, transportation, operations, and maintenance of the SPS program systems. Included are the satellite and ground receiving station systems, as well as the necessary support systems such as space construction and support and transportation.

1.1 SATELLITE

This element includes the hardware and software located in geosynchronous orbit (GEO) for the collection of solar energy, conversion to electrical energy, and transmission of electrical energy in microwave form to earth.

1.1.1 ENERGY CONVERSION

This element includes the components required to collect solar energy, convert the solar energy to electrical energy, condition the electrical energy, and transport it to the interface subsystem (WBS No. 1.1.6).

1.1.1.1 STRUCTURE

This element includes all necessary members to support the concentrators, solar blankets, and other energy conversion subsystem hardware. It includes structural beams, beam couplers, cables, tensioning devices, and secondary structures which are required as an interface between the primary structure and the mounting attach points of components, assemblies, and subsystems including mechanisms such as drive motors located at the interface for yoke rotation.

1.1.1.2 CONCENTRATORS

This element concentrates the solar energy onto the solar blanket to increase the energy density on the conversion device. It includes the reflective material and any integral attach points required for mounting. Excluded are tools and support equipment required for deployment and tensioning.

1.1.1.3 SOLAR BLANKET

This element converts solar energy to electrical energy and provides power to the power distribution and conditioning buses. It includes the photovoltaic conversion cells, coverplates, substrate, electrical interconnects, and any integral attach points required for mounting. Excluded are tools and support equipment required for deployment and tensioning.

1.1.1.4 POWER DISTRIBUTION AND CONDITIONING

This element includes the power conductors, switch gear, and conditioning equipment and slip rings required to transfer power from the solar blanket to the interface subsystem power distribution elements. Also included are electrical cables and harnesses required to distribute power to equipment located on

the energy conversion structure, plus batteries or storage medium for information system and attitude control. Excluded are data buses which are included in the information management and control subsystem (WBS No. 1.1.3).

1.1.1.5 THERMAL CONTROL

This element includes any component used to modify the temperature of the energy conversion subsystem components. It includes coldplates, heat transfer, and radiator devices, as well as insulation, thermal control coatings, and finishes. Excluded are paints or finishes applied to components during their manufacturing sequence.

1.1.1.6 MAINTENANCE

This element provides for in-place repair or replacement of components and includes work stations, tracks, access ways, and in situ repair equipment.

1.1.2 POWER TRANSMISSION

This element receives dc electrical power from the interface subsystem, conditions the power, converts it to microwave energy, and radiates the energy to the ground receiving station. Included are power distributions from the interface subsystem, dc-to-RF conversion devices, control and monitoring equipment, and antenna radiating elements.

1.1.2.1 STRUCTURE

This element includes all members necessary to support the transmitter subarrays and other power transmission subsystem hardware. It includes structural beams, beam couplers, cables, tensioning devices, and secondary structures, plus the mechanisms/drive gears for antenna orientation.

1.1.2.2 TRANSMITTER SUBARRAYS

This element includes all the hardware required for generation, distribution, phase control, and radiation of microwave energy. This includes the subarray structure, waveguides, power amplifiers, phase shifters and control electronics, and power harnesses. Also included are thermal control devices and finishes that are manufactured as an integral part of the subarray.

1.1.2.3 POWER DISTRIBUTION AND CONDITIONING

This element includes the power conductors, switch gear, and conditioning equipment required to transfer power from the interface subsystem to the subarray wiring harnesses and to any other power-consuming/storage equipment located on the power transmission structure, such as batteries.

1.1.2.4 THERMAL CONTROL

This element includes any component used to modify the temperature of power transmission subsystem components. It includes coldplates, heat transfer and radiator devices, as well as insulation, thermal control coatings, and finishes. Excluded are paints and finishes applied to components during their

manufacturing sequence and thermal control devices that are an integral part of another component.

1.1.2.5. CONTROL--PHASE REFERENCE

This element provides the reference phase for all subarray phase conjugating circuits. This includes the reference oscillator signal distribution equipment and components that commonly serve all subarrays.

1.1.2.6 MAINTENANCE

This element provides for in-place repair or replacement of components and includes work stations, tracks, access ways, and in situ repair equipment.

1.1.3 INFORMATION MANAGEMENT AND CONTROL

This element includes those components that process information on board the satellite. This includes sensing, signal conditioning, formatting, computations, formulation and signal routing, plus instrumentation requirements for MWPTS voltage/control measurement on the antenna.

1.1.4 ATTITUDE CONTROL AND STATIONKEEPING

This element includes the components required to orient and maintain the satellite's position and attitude in GEO. Included are sensors, reaction wheels, chemical and electric propulsion hardware, and propellants.

1.1.5 COMMUNICATIONS

This element includes the hardware to transmit and receive intelligence among the various SPS elements. This includes communication of both data and voice between the SPS and the control center, as well as among the various cargo and personnel vehicles. Excluded is intravehicular and intrasatellite communications.

1.1.6 INTERFACE (ENERGY CONVERSION/POWER TRANSMISSION)

This element provides the movable interface between the energy conversion subsystem and the power transmission subsystem. A 360° rotary joint and an antenna elevation mechanism are required to maintain proper alignment of the transmitter with the ground receiving station. Included are structure, mechanisms, power distribution, thermal control, and maintenance hardware.

1.1.6.1 STRUCTURE

This element includes all members necessary to provide a mechanical interface between the primary structures of the energy conversion subsystem and the power transmission subsystem. It includes beams, beam couplers, cables, tensioning devices, and secondary structures. Excluded are elements of the drive assembly which are included in mechanisms (WBS No. 1.1.6.2).

1.1.6.2 MECHANISMS

This element of the interface segment includes components required to support rotation and elevation of the power transmission subsystem. Included are bearings, gears, drive motors, and passive supports. Drive motors are located on the energy conversion segment.

1.1.6.3 POWER DISTRIBUTION

This element provides for the transfer of electrical power through the interface. It includes slip ring, brush assemblies, feeders, and insulation.

1.1.6.4 THERMAL CONTROL

This element includes any component used to modify the temperature of interface subsystem components. It includes coldplates, heat transfer and radiator devices, as well as insulation, thermal control coatings, and finishes. Excluded are paints or finishes applied to components during their manufacturing sequence.

1.1.6.5 MAINTENANCE

This element provides for in-place repair or replacement of components and includes work stations, tracks, access ways, and in situ repair equipment.

1.1.7 SYSTEMS TEST

This element includes the hardware, software, and activities required for ground-based systems tests including qualification tests and other development tests involving two or more subsystems or assemblies. It includes the production, assembly, integration, and checkout of satellite system hardware into a full or partial system test article. It also includes the design, development, and manufacture of special test equipment, test fixtures, and test facilities that are not included in other elements such as ground support facilities. Also included are the planning, documentation, and actual test operations.

1.1.8 GROUND SUPPORT EQUIPMENT (GSE)

This element includes all ground-based hardware required in support of handling, servicing, test, and checkout of the satellite subsystems. It also includes special hardware required for simulations and training.

1.1.9 PILOT PLANT/TEST ARTICLE

The SPS proof-of-concept pilot plant and supporting test validations are included in this element. It covers a space test vehicle, STS transportation, construction operations/test activity, and ground receiving facility.

1.2 SPACE CONSTRUCTION AND SUPPORT

This element includes all hardware and activities required to assemble, check out, operate, and maintain the satellite system. Included are space stations, construction facilities, support facilities and equipment, and manpower operations.

1.2.1 CONSTRUCTION FACILITIES

This element includes the facilities, equipment, and operations required to assemble and check out the satellite system. Included are crew life support facilities, the central control facility, fabrication and assembly facilities, cargo depots, and operations.

1.2.1.1 WORK SUPPORT FACILITIES

This element includes the facilities and equipment required for satellite assembly and checkout. Included are beam fabricators, manipulators, assembly jigs, installation and deployment equipment, and cargo storage depots. Excluded are the facilities related to crew support.

1.2.1.2 CREW SUPPORT FACILITIES

This element includes the facilities and equipment required for the life support and well-being of the crew members. Included are living quarters, center control facilities, recreation facilities, and health facilities of the satellite construction base.

1.2.1.3 OPERATIONS

This element includes the planning, development, and conduct of operations at the construction facility. It includes both the direct and support personnel and the expendable maintenance supplies required for satellite assembly and checkout.

1.2.2 LOGISTICS SUPPORT FACILITIES

This element includes the hardware, software, and operations required in low earth orbit (LEO) to support the construction and operations and maintenance of the satellite system. Included are crew life support facilities, cargo and propellant depots, and vehicle servicing facilities necessary for the receiving, storage, and transfer of cargo and personnel destined for a construction base or operational satellite located in GEO.

1.2.2.1 WORK SUPPORT FACILITIES

This element includes the facilities and equipment required to provide logistics support in LEO. Included are heavy-lift launch vehicle (HLLV) and orbital transfer vehicle (OTV) docking stations, payload handling equipment, and cargo and propellant storage depots. Excluded are facilities related to crew support.

1.2.2.2 CREW SUPPORT FACILITIES

This element includes the facilities and equipment required for the life support and well-being of the crew members. Included are living quarters, recreation facilities, and health facilities of the LEO Base.

1.2.2.3 OPERATIONS

This element includes the planning, development, and conduct of operations at the logistics support facility. It includes both the direct and support personnel and the expendable maintenance supplies required for logistics support.

1.2.3 O&M SUPPORT FACILITIES

This element includes the facilities, equipment, and operations required in GEO to support the operations and maintenance of the satellite system. Included are the on-orbit monitor and control facility and the life support facilities and equipment required to provide comfortable, safe living quarters for the resident crew members.

1.2.3.1 WORK SUPPORT FACILITIES

This element includes the facilities and equipment required for operation and maintenance of the satellite system. Included are satellite monitor and control stations and any centralized repair facilities not included under maintenance (WBS Numbers 1.1.1.6, 1.1.2.6, and 1.1.6.5).

1.2.3.2 CREW SUPPORT FACILITIES

This element includes the facilities and equipment required for the life support and well-being of the crew members. Included are living quarters, recreation facilities, and health facilities.

1.2.3.3 OPERATIONS

This element includes the planning, development, and conduct of operations at the O&M support facility. It includes both the direct and support personnel and the expendable maintenance supplies required in GEO for satellite operations and maintenance.

1.3 TRANSPORTATION

This element includes all space transportation required to support the satellite system assembly and operation; and the ground support facilities to provide a launch, recovery, propellant, logistics, and operational capability. Included are the launch to LEO and the orbit-to-orbit transfer of all hardware, materials, and personnel required during the construction and lifetime operation of the satellite system.

1.3.1 HEAVY-LIFT LAUNCH VEHICLE (HLLV)

This element includes the HLLV vehicles and operations required to support the satellite system assembly and operation. Included is the launch to LEO of all personnel, space construction and support equipment, satellite system hardware, OTV's, propellants, and other consumables required throughout the satellite construction and operational lifetime.

1.3.1.1 HLLV VEHICLE

This element includes the vehicle fleet procurement required to support the SPS project.

1.3.1.2 HLLV OPERATIONS

This element includes the necessary vehicle operations (user charge per flight including payload integration) required to support the SPS project...

1.3.2 CARGO ORBITAL TRANSFER VEHICLE (COTV)

This element includes the COTV vehicle and operations required to support the satellite system assembly and operation. Included is the LEO-to-GEO transfer of space construction and support equipment, satellite system hardware, spares, and propellants required throughout the satellite lifetime.

1.3.2.1 COTV VEHICLES

This element includes the vehicle fleet procurement required to support the SPS project.

1.3.2.2 COTV OPERATIONS

This element includes the necessary vehicle operations (user charge per flight including payload integration) required to support the SPS project.

1.3.3 PERSONNEL LAUNCH VEHICLE (PLV)

This element includes the PLV and cargo vehicles of the STS (Space Shuttle), growth Shuttle, and Shuttle derivatives, including operations required to support the precursor (pilot plant), LEO base, and SCB. Also included is the launch to LEO and return of all personnel and cargo.

1.3.3.1 PLV VEHICLES

This element includes the vehicle fleet procurement to support early STS vehicle requirements for personnel/cargo transfer from earth to LEO as needed to support elements of the pilot plant, LEO base, and construction facility.

1.3.3.2 PLV OPERATIONS

This element includes the necessary vehicle operations (user charge per flight including payload integration) required to support early SPS project activities.

1.3.4 PERSONNEL ORBITAL TRANSFER VEHICLE (POTV)

This element includes the POTV vehicles and operations required to support the satellite system assembly and operation. Included is the LEO to GEO and return transfer of all personnel and priority cargo required throughout the satellite construction and operational periods.

1.3.4.1 POTV VEHICLES

This element includes the vehicle fleet procurement required to support the SPS project.

1.3.4.2 POTV OPERATIONS

This element includes the necessary vehicle operations (user charge per flight including payload integration) required to support the SPS project.

1.3.5 PERSONNEL MODULE (PM)

This element includes the PM units and operations required to support the satellite system assembly and operation. Included is the LEO to GEO and return transfer of all personnel and critical hardware items required throughout the satellite construction and operational periods. The PM provides a crew habitat during the orbit-to-orbit transfers of personnel.

1.3.5.1 PM VEHICLES

This element includes the PM unit procurement required to support the SPS project.

1.3.5.2 PM OPERATIONS

This element includes the necessary operations (user charge per flight including payload integration) required to support the SPS project.

1.3.6 INTRA-ORBITAL TRANSFER VEHICLE (IOTV)

This element includes the IOTV vehicles and operations required to support satellite system assembly and operation. Included is the intra-orbit transfer of cargo between the HLLV, COTV, construction facility, logistics support facility, and operational satellites.

1.3.6.1 IOTV VEHICLES

This element includes the necessary vehicle fleet procurement required to support the SPS project.

1.3.6.2 IOTV OPERATIONS

This element includes the necessary vehicle operations (recurring refurbishment and propellant costs) required to support the SPS project.

1.3.7 GROUND SUPPORT FACILITIES

This element includes all land, buildings, roads, shops, etc., required to support the cargo handling, launching, recovering, refurbishment, and operations of the space transportation system.

1.3.7.1 LAUNCH FACILITIES

This element includes the design and construction of the actual launch facility and its associated equipment. Included are land, buildings, and equipment required to support the various crews. It also includes the required control centers and administrative facilities.

1.3.7.2 RECOVERY FACILITIES

This element covers the design, construction, and equipping of the actual recovery facilities.

1.3.7.3 FUEL FACILITIES

This element includes fuel production facilities, storage and handling facilities, transportation, and delivery and safety facilities for both the fuel and the oxidizer. Also included are the facilities for fuels used in the various orbital transfer facilities.

1.3.7.4 LOGISTICS SUPPORT

This element includes the land, buildings, and handling equipment for the receiving, inspection, and storage and packaging of all payloads to be launched except for fuels and oxidizers.

1.3.7.5 OPERATIONS

This element includes the planning, development, and conduct of operations at the ground support facilities. It includes both the direct and support personnel and the expendable maintenance supplies required for the ground support facilities operation and maintenance.

1.4 GROUND RECEIVING STATION

This element includes the land, facilities, and equipment that comprise the ground subsystems utilized to receive the radiated microwave power beam and to provide the power at the required voltage and type of current for entry into the national power grid. Also included are the equipment and facilities necessary to provide operational control over the satellite.

1.4.1 SITE AND FACILITIES

This element encompasses the site and facilities for the ground receiving station system which includes the rectenna, grid interface, and satellite control subsystems. Included are the land, site preparation, roads, fences, utilities, lightning protection, buildings, and maintenance equipment required to house and support the other ground station subsystems.

1.4.2 RECTENNA SUPPORT STRUCTURE

This element includes the hardware, materials (steel and concrete), and assembly operations necessary to erect the physical support for the rectenna array elements of WBS No. 1.4.3.

1.4.3 POWER COLLECTION

This element includes the antenna array elements associated with the actual reception and rectification of the microwave radiation. These elements are in series and parallel as required to deliver the required output voltage and

current. Also included are those components that accept the dc power from the array elements and route, control, convert, and switch this power for delivery to power conversion stations of the grid interface.

1.4.4 CONTROL

This element includes the hardware that will be used to monitor and control the satellite from the ground. Included are telemetry, tracking, communications, monitoring of microwave beam characteristics, computing phase corrections, and providing frequency standard signals for the satellite. Functional requirements provide for signal conditioning, formatting, software, computations, and signal routing.

1.4.5 GRID INTERFACE

This element includes the power conversion equipment that receives the electrical power from the power collection subsystem and conditions/converts it to a high voltage dc or ac power acceptable for input into the national power grid. Also included are those components necessary to route, control, and switch this power into the national power grid.

1.4.6 OPERATIONS

This element includes the planning, development, and conduct of operations at the ground receiving station. It includes both the direct and support personnel and the expendable maintenance supplies required for the ground station operation and maintenance.

1.5 MANAGEMENT AND INTEGRATION

This element includes all efforts and material required for management and integration functions at the systems level and program level. It encompasses the following functions:

- | | |
|---------------------------------|---|
| a) Program Administration | (f) Support Management |
| b) Program Planning and Control | (g) Quality Assurance Management |
| c) Contracts Administration | (h) Configuration Management |
| d) Engineering Management | (i) Data Management |
| e) Manufacturing Management | (j) Systems Engineering and Integration |

This element sums all direct efforts required to provide management control, including planning, organizing, directing, and coordinating the project to ensure that overall project objectives are accomplished. These efforts overlay the functional work areas (e.g., engineering, manufacturing, etc.) and assure that they are properly integrated. This element also includes the efforts required in the coordination, gathering, and dissemination of management information. Also included are the engineering efforts related to the establishment and maintenance of a technical baseline for a system by generation of system configuration parameters, criteria, and requirements. It includes requirements analysis and integration, system definition, system test definition, interfaces, safety, reliability and maintainability. It also includes those efforts required to monitor the system development and operations to ensure that the design conforms to the baseline specifications.

1.5 MASS CONTINGENCY

This element provides for a cost contingency to offset the variability of mass estimates/determinations on items of SPS hardware/software as planned for deployment in space. This would potentially involve the WBS categories of...
1.1, Satellite; 1.2, Space Construction and Support; and 1.3, Transportation.

APPENDIX B
SATELLITE POWER SYSTEM
COST ESTIMATES

SOLAR PHOTOVOLTAIC CELLS
CONCENTRATION RATIO (CR)—2 EFF.
THREE-TROUGH PLANAR
END-MOUNTED ANTENNA(S)

APPENDIX B

SATELLITE POWER SYSTEM

COST ESTIMATES

B.0 INTRODUCTION

This appendix contains results of extensive analyses to identify cost estimates for hardware and activities of the Satellite Power System (SPS) program. It is divided into sections covering a description of SPS configurations and technical characteristics, details on study guidelines, a discussion of costing methodology, line item cost summaries, and supporting detail on the analyses and elements of cost in each area.

In order to promote a complete and understandable comparison of SPS costs, and to maintain a compatible economic and programmatic reference, the SPS work breakdown structure of Appendix A was used as a framework for cost and programmatic definition. This has provided for the development of costs at each of the intersects identified on the WBS matrix of Figure B-1. Approximately 300 line items were identified within each category of DDT&E, theoretical first SPS, SPS investment, and operations as applied to the SPS concepts studied.

B.1 SPS CONCEPTS

Five SPS concepts were costed in detail during the Exhibit D contract activity. Each concept utilized a satellite configuration from one of the two "families" shown in Figure B-2. The three-trough planar configurations have masses averaging 32.7×10^6 kg versus 18.5×10^6 kg for the reflector/sandwich configurations. Other differences between these families are variable power output at the utility interface, concentration ratios, and relative mass per kW at the utility interface.

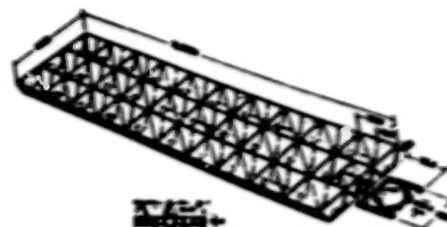
| HARDWARE AND ACTIVITIES | PROGRAM PHASE | | | |
|--|---------------|-----------------------|------------------------------|------------|
| | DDT&E | THEORETICAL FIRST SPS | SPS INVESTMENT PER SATELLITE | OPERATIONS |
| 1.0 SATELLITE POWER SYSTEM | | | | |
| 1.1 SATELLITE | | | | |
| 1.1.1 ENERGY CONVERSION | | | | |
| 1.1.2 POWER TRANSMISSION | | | | |
| 1.1.3 INFORMATION MANAGEMENT & CONTROL | | | | |
| 1.1.4 ATTITUDE CONTROL AND STATIONKEEPING | | | | |
| 1.1.5 COMMUNICATIONS | | | | |
| 1.1.6 INTERFACE (ENERGY CONVERSION/POWER TRANSMISSION) | | | | |
| 1.1.7 SYSTEMS TEST | | | | |
| 1.1.8 GSE | | | | |
| 1.1.9 PILOT PLANT | | | | |
| 1.2 SPACE CONSTRUCTION AND SUPPORT | | | | |
| 1.2.1 CONSTRUCTION FACILITIES | | | | |
| 1.2.2 LOGISTICS SUPPORT FACILITIES | | | | |
| 1.2.3 GSE SUPPORT FACILITIES | | | | |
| 1.3 TRANSPORTATION | | | | |
| 1.3.1 SPS VEHICLE ALLV | | | | |
| 1.3.2 COTV | | | | |
| 1.3.3 STS PLV | | | | |
| 1.3.4 POTV | | | | |
| 1.3.5 PM | | | | |
| 1.3.6 LOTV | | | | |
| 1.3.7 GROUND SUPPORT FACILITIES | | | | |
| 1.4 GROUND RECEIVING STATION | | | | |
| 1.4.1 SITE AND FACILITIES | | | | |
| 1.4.2 RECTENNA SUPPORT STRUCTURE | | | | |
| 1.4.3 POWER COLLECTION | | | | |
| 1.4.4 CONTROL | | | | |
| 1.4.5 GRID INTERFACE | | | | |
| 1.4.6 OPERATIONS | | | | |
| 1.5 MANAGEMENT AND IMPROVEMENT | | | | |

Figure B-1. SPS Work Breakdown Structure



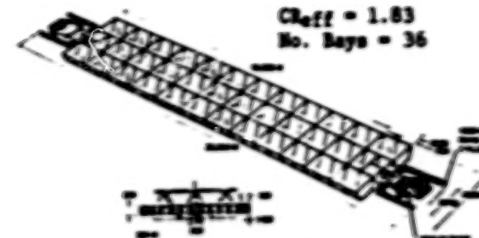
$CR_{eff} = 1.82$
 No. Bays = 30
 Mass = 31.63×10^3 kg
 Power at Utility I/V = 5.00 CW
 Specific Mass = 6.33 kg/kW

SPS CR-2 REFERENCE CONFIGURATION
(3-TROUGH/PLANAR/KLYSTRON)



$CR_{eff} = 1.83$
 No. Bays = 30
 Mass = 26.7×10^3 kg
 Power at Utility I/V = 5.6 CW
 Specific Mass = 4.77 kg/kW

SPS CR-2 MAGNETRON CONFIGURATION
(3-TROUGH/PLANAR)



$CR_{eff} = 1.83$
 No. Bays = 36
 No. Panels = 72
 Solar Array Power Generated = 11.46 CW
 Power at Utility = 5.22 CW
 Sp. Mass = 7.66 kg/kW_{util}

SPS CR-2 SOLID-STATE CONFIGURATION
(3-TROUGH/PLANAR/DUAL
END-MOUNTED ANTENNA)

GaAs Solar Panels
 Effective CR = 5.2
 Specific Mass =
 8.48 kg/kW Util. I/V

Power at Utility Interface =
 1.21 CW per antenna
 (2.42 CW total)
 Mass with Growth (dry) =
 20.53×10^3 kg

SOLID-STATE GaAs SANDWICH CR-5 CONFIGURATION
(DUAL REFLECTORS/ANTENNAS)



MBG Solar Panels
 Effective CR = 5.2
 Specific Mass =
 5.35 kg/kW Util. I/V

Power at Utility Interface =
 1.51 CW per antenna
 (3.06 CW total)
 Mass with Growth (dry) =
 16.39×10^3 kg

SOLID-STATE GaAlAs MBG SANDWICH CR-5 CONFIGURATION
(DUAL REFLECTORS/ANTENNAS)

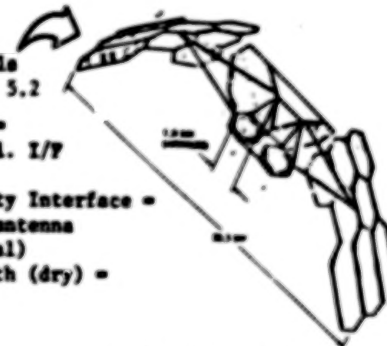


Figure B-2. Rockwell SPS Satellite Concepts - 1980

The SPS reference satellite configuration consists of a three trough-planar solar cell array with concentrators utilizing klystron tubes for powering the microwave transmission array. This satellite transmits microwave energy to a single receiving antenna at a ground based location where it is converted into electrical power for entry into the utility grid.

This same solar array approach is utilized in a second concept, excepting those design modifications that accommodate the characteristics and requirements of a magnetron tube used for the generation of microwave energy. The specific mass of the configuration is 4.77 kg/kW with a total mass of 26.7×10^3 kg including growth. GaAs solar cell power capabilities dictate the overall length of 16,900 m.

A third configuration utilizes dual end-mounted solid state antennas that provide one-half the total power output of the satellite (3.68 GW per antenna). The specific mass of this satellite is 7.66 kg/kW based on calculated power at the utility interface.

The solid-state sandwich configurations of the second family consist of dual mirror reflector surfaces that focus the sun's energy upon solar cell blankets forming a part of the antenna array sandwich of the microwave generation system. The primary mirror is rotated about the satellite's reflector axis so that the dual spacetennas remain locked on the earth based receiving antennas. Specific mass of these concepts vary from 8.48 kg/kW to 5.35 kg/kW due to the type of solar cell used.

B.2 COSTING GROUND RULES AND GUIDELINES

Guidelines and assumptions used in the development of cost and programmatic aspects of this study acknowledge study parameters and criteria, the availability of supporting programs, SPS development schedules, and provide a basis for the uniform development of cost and programmatic.

1. Key dates of program planning:

- 1981-1986 Ground-Based Exploratory Development (Research and Development)
- 1981-1987 Key Technology Advancement Activities
- 1990 Decision Point for SPS Commercialization (Phase C/D)
- 2000 SPS Initial Operational Capability

2. Report costs at WBS levels in terms of:

- SPS development costs and TFU (theoretical first unit) costs
- Average initial capital investment cost per satellite
- Replacement capital investment (RCI) cost and operations and maintenance (O&M) cost per satellite per year

3. Cost estimates to be projected in 1979 dollars.

4. Maximum use shall be made of cost data from past SPS studies and associated government/contractor data files.

5. SPS options shall provide a 300 GW capability at the utility interface with a total capacity of 300 GW by year 2030.

6. Overall SPS lifetime will be 30 years with minimum maintenance and no salvage value or disposition costs.
7. Complete construction and assembly will occur at geosynchronous orbit.
8. Calculations are based on 0% launch losses.
9. Program management and SE&I (management and integration) are costed at 5% of all other Level 2 costs.
10. 25% mass contingency is costed as a 15% cost contingency on SPS WBS items of the satellite (1.1) and space construction and support (1.2). Space transportation (1.3) masses include a 25% contingency on mass in lieu of the 15% cost contingency.
11. Supporting program considerations:
 - Space Shuttle
 - Solar Electric Power System
 - Interim Upper Stage
 - Personnel OTV

B.3 COSTING METHODOLOGY

The approach followed in developing cost estimates for the SPS program was based on the maximum use of results from the current study, a reliance on accomplishments of past contract activity, and the use of other contract and company sponsored work. The calculation of cost estimates and the organization/reporting of cost data was accomplished through the use of Rockwell's flexible Cost/Risk Analysis Computer Program as adapted for the SPS. This computer program has been continuously updated to incorporate expanded and lower level indentures of SPS-WBS definition including those revisions required as a result of design variations within the five concepts.

Since starting work on Exhibit D, the data base of existing and proved CER's was expanded by special analyses of technical design definitions to obtain cost estimates of SPS assemblies and components. This included analyses on satellite secondary structures and the klystron, magnetron, and solid state designs of the microwave generation/transmission system.

As to the computer program and cost calculations, there are a series of equations that deal with four basic types of cost accounts and phases of the program - DDT&E, initial capital investment, replacement capital investment, and operations and maintenance.

The DDT&E equation (CD) estimates the cost of the design, development, and test/evaluation of WBS line items for the satellite, space construction and support, transportation, and ground receiving station, plus management and integration support. Management and integration are costed as a separate line item at 5% of all other level two costs of the WBS. Because of the gross nature of the level of information/definition on systems test and GSE (ground support equipment), the cost of system test hardware, and system test operations, has been assumed to be one-half of the satellite system average unit investment costs. A 10% factor of satellite DDT&E is used for GSE.

Appropriate inputs for the DDT&E CERs are the applicable total system mass, area, or power. A development factor is provided in the equation (DF) to adjust the cost to reflect only that portion of the total system mass, area or power considered necessary for development of the complete system where it is not required to develop the total mass, area or power. The CD cost equation also allows for the application of a complexity factor (CF) to adjust the cost results when it is determined that the item being estimated is either more or less complex than the CER base data.

Capital investment (ICI) cost equations estimate the initial capital investment cost of hardware items as a function of their mass, area or power. The ICI cost equation is expressed in four different forms—CLRM, CTFU, CTB, and CIPS. The CLRM (cost of lowest repeating module) equation requires that the input correspond to the mass, area or power of the lowest repeating module (M). This is necessary because of the physical scale of the SPS and the production quantities required for many of the hardware elements. It is not reasonable to estimate the SPS initial capital investment cost as a historical function of the entire SPS mass, area or power. Instead, it is desirable to cost the number of repeating modules required per satellite to establish the satellite theoretical first-unit cost (TFU), and to input the satellite TFU cost into a progress (learning) function for the quantity of satellites required to calculate the average unit cost (CTB - cost to build). This calculation involves two steps in the cost equations. The first step (CLRM) is simply the portion of the equation which estimates the theoretical first repeating module cost as discussed above. The second step (CTFU) has the progress function incorporated into the equation for the quantity of repeat modules required for the first satellite. It automatically takes into account the progress over production quantities required when calculating the cost to build an average unit over the total option quantity. This CTB calculation is then the basis of CIPS (cost of investment per system), where the number of units to construct a satellite option are divided by the option quantity and then multiplied by the CTB. In some initial investment cost equations, such as those of SPS transportation, the space vehicle has a service life that is greater than that needed to construct a single satellite. The CIPS calculation provides accurate system cost assessments on an individual SPS basis.

At the current level of SPS definition, it was difficult to decide just what is a repeating module. It is often impossible to know with any certainty just what portion of the total mass is appropriate to run through the equation as a module. It is just as difficult to identify how many distinct types or designs of modules will be required for any subsystem or assembly. In such cases, the study simply assumed a module mass (or area or power) based on engineering best judgment.

Replacement capital investment (RCI) CERs simply provide for the multiplication of the annual spares fraction (R) of each system by that system's cost to build in order to arrive at an RCI cost per satellite per year. An "R" factor was identified by dividing the number of equivalent satellite replacements over 30 years with a value equal to the number of satellites (satellite option) times 30 years.

An objective of the cost analysis task involving replacement capital investment was to segregate costs associated with replacement capital and

operations/maintenance expenditures that occur before or after SPS-IOC (initial operations capability). A new programming feature was therefore, added to the Rockwell computer program that acknowledges this calculation and presents pre and post-IOC expenditures over the life of each SPS.

Operations and maintenance costs (CO&M) were estimated in terms of O&M cost per satellite per year. These costs include those expenditures incurred in day-to-day operations beginning with SPS initial operating capability (IOC) and continuing over the life of each satellite. They consist of wages of operations and maintenance personnel, minor repairs and adjustments to systems to maintain an ordinarily efficient operating condition, expendables and consumables, launch costs for delivery and transfer of on-orbit personnel and cargo resupply of expendables and consumables, etc.

The cost methodology seeks to account for five separate effects which influence SPS cost. These are scaling, specification requirements, complexity, the degree of automation, and production progress. Scaling refers to the relationship in cost between items varying in size, but similar in type. Economies of scale usually assure that such a relationship will not be strictly linear, but rather as size increases, cost per unit of size will decrease. The slope of this relationship is reflected by the equation exponent which results from the regression analysis of the data used to develop the cost estimating relationship.

Specification requirements have been accounted for by normalizing the CER data base to manned spacecraft specification levels using factors from the RCA Price Model.¹ From that model, an average cost factor to adjust MILSPEC to manned spacecraft is around 1.75 for DDT&E and 1.6 for production cost. Under the assumption that some relaxation of Apollo-type specifications can be made for the SPS, a factor of 1.5 was assumed for both DDT&E and production cost. Furthermore, it was assumed that a factor of 3.0 would adjust commercial specifications to SPS requirements. Therefore, military or commercial cost data used in the CERs were adjusted upward by factors of 1.5 and 3.0, respectively.

The cost equations allow a complexity factor input to adjust the cost result when it is determined that the item being estimated is either more or less complex than the listed CER data base.

The degree of automation is accounted for in certain cost equations through an adjustment to the CER coefficient by the tooling factors given in Table B-1. The effect of tooling is dependent upon the annual production rate. Higher production rates allow harder tooling and, thus, effect cost reductions. The tooling factors are used only on those CERs which are based on historical aerospace programs with limited annual production rates. Tooling factors are not used on those CERs which are based on data already reflecting automated production techniques (e.g., the commercial electronics data for the microwave antenna CER).

¹Equipment Specification Cost Effect Study, Phase II Final Report, Nov. 30, 1976, by RCA Government Systems Division.

Table B-1. SPS Tooling Factors

| AVERAGE ANNUAL PRODUCTION RATE (AAPR) | TOOLING FACTOR (TF) | PROGRESS FRACTION (ϕ) |
|---|---------------------------|------------------------------------|
| 1-2 | 1.0 | 0.80 |
| 3-5 | 0.9 | 0.80 |
| 6-9 | 0.8 | 0.80 |
| 10-19 | 0.7 | 0.85 |
| 20-39 | 0.6 | 0.85 |
| 40-69 | 0.5 | 0.85 |
| 70-109 | 0.4 | 0.85 |
| 110-159 | 0.3 | 0.90 |
| 160-219 | 0.2 | 0.90 |
| 220-999 | (AAPR) ^{-0.38} | 0.90 |
| 1000-9999 | (AAPR) ^{-0.38} | 0.95 |
| 10,000 | (AAPR) ^{-0.38} | 0.98 |

The decreasing cost effects of progress due to production process improvements or direct labor learning are accounted for through standard progress functions. Many SPS components will be mass produced in a capital intensive manner and will experience little labor learning. Other SPS hardware items, however, will be produced at very low annual rates, much in the labor-intensive manner of historical spacecraft programs, and therefore would experience learning. (Technically distinguishable from learning, but still predictable with the same form of exponential function, are the effects of production process improvement. In this model, when progress functions are used, they are meant to account for both of these effects.) A constant relationship has been assumed between the progress fraction and the annual production rate as given in Table B-1.

As required by costing ground rules and assumptions, all CERs are in terms of 1979 dollars. The study did assume 1990 technology and 1990 supply/demand conditions which, in some cases, resulted in differential (non-general) price inflation or deflation between 1979 and 1990 being included in the CERs. Specifically, it was assumed that composite raw material prices and some electronic component prices will decrease relative to general prices while aluminum coil stock prices will increase relative to general prices. Such effects are allowed for by the CERs, but only to the extent that the expected price changes differ from expected general price changes. The CERs affected are the antenna structure CER, the power source structure CER, and the microwave antenna CER.

Definitions of SPS cost model terms and equation abbreviations are presented in Table B-2. Figure B-3 illustrates the format of cost data sheets developed for each WBS line item of the particular concept as produced by the SPS dedicated computer program.

Table B-2. Definitions of SPS Computer Cost Model Terms

| | |
|---------------|---|
| C | = COST IN MILLIONS OF 1979 DOLLARS |
| CD | = DDT&E COST |
| CD CER | = DDT&E COST ESTIMATING RELATIONSHIP (CER) |
| CDEXP | = DDT&E SCALING EXPONENT |
| CER | = COST ESTIMATING RELATIONSHIP |
| CF | = COMPLEXITY FACTOR |
| CICER | = INITIAL CAPITAL INVESTMENT COST ESTIMATING RELATIONSHIP (CER) |
| CIEXP | = INITIAL CAPITAL INVESTMENT COST SCALING EXPONENT |
| CTB | = COST TO BUILD AN ITEM |
| CIPS | = INVESTMENT COST PER SATELLITE POWER SYSTEM |
| CLRM | = LOWEST REPEATING MODULE COST |
| COBM | = OPERATIONS AND MAINTENANCE COST PER SPS PER YEAR |
| CRCI | = REPLACEMENT CAPITAL INVESTMENT COST PER SPS PER YEAR |
| CTFU | = THEORETICAL FIRST UNIT COST |
| DDT&E | = DESIGN, DEVELOPMENT, TEST AND EVALUATION |
| DF | = DEVELOPMENT FRACTION |
| E | = $1.0 + \log(\text{PHI}) \div (2.0)$ |
| ICI | = INITIAL CAPITAL INVESTMENT |
| INV. PER SAT. | = AVERAGE UNIT INVESTMENT COST (2 THRU N) |
| M | = MASS, POWER, AREA OF LOWEST REPEATING MODULE |
| #RM | = NUMBER OF REPEATING MODULES |
| OPS | = OPERATIONS |
| OBM | = OPERATIONS AND MAINTENANCE COST PER SPS PER YEAR |
| PRE-IOC | = BEFORE SPS INITIAL OPERATIONAL CAPABILITY |
| POST-IOC | = AFTER SPS INITIAL OPERATIONAL CAPABILITY |
| PHI | = PROGRESS FRACTION |
| R | = ANNUAL SPARES FRACTION |
| RCI | = REPLACEMENT CAPITAL INVESTMENT COST PER SPS PER YEAR |
| T | = TOTAL (MASS, POWER, AREA) PER SYSTEM |
| TF | = TOOLING FACTOR |
| TFU | = THEORETICAL FIRST UNIT |
| Z1 | = TFU REQUIREMENT |
| Z2 | = SPS OPTION QUANTITY |
| Z3 | = TOTAL SPS REQUIREMENT PER OPTION |
| Z4 | = ITEMS NEEDED TO CONSTRUCT SATELLITE OPTION |
| Z5 | = ITEMS NEEDED FOR OBM OF THE SATELLITE OPTION |
| Z6 | = RATIO OF Z4 to Z5 FOR PRE-IOC AND POST-IOC CALCULATIONS |

B.4 SPS PROGRAM COST BREAKDOWNS

A summary of SPS estimates presented in this section emphasizes costs of the updated Rockwell SPS reference three-trough/planar/klystron concept where line item detail is presented for DDT&E, TFU, investment per SPS, and RCI/O&M phases.

An overall comparison of five SPS concepts was developed during the study as identified in Table B-3. Option quantities and power output at the utility interface are consistent with the provision to establish a 300 GW capability at 30 years. DDT&E values represent non-recurring front-end program costs estimated for each concept. TFU costs represent hardware, software, and services needed to build the first unit. Investments per satellite and RCI/O&M estimates during construction operations equal the average SPS cost based on the procurement option. Post-IOC operations cost is the annual amount required to maintain each SPS system after it becomes operational. Installation costs per kW are shown in the last column.

Table B-3. SPS Concept Comparisons

| SPS CONCEPT | SPS OPTION QUAN. | 1979 DOLLARS (BILLIONS) | | | | | |
|--|------------------|-------------------------|------|--------------------------|-----------------------------------|---------------------------------|-------------------------|
| | | DDT&E | TFU | INVESTMENT PER SATELLITE | CONSTRUCTION OPERATIONS (RCI/O&M) | POST-IOC OPERATIONS (\$/SAT/YR) | INSTALLATION COST \$/kW |
| REFERENCE UPDATE GaAs PLANAR-KLYSTRON (5.00 GW UTIL) | 60 | 33.6 | 53.6 | 12.7 | 2.3 | 0.14 | 83000 |
| | | | | 15.0 | | | |
| THREE-TROUGH GaAs PLANAR-MAGNETRON (5.60 GW UTIL) | 54 | 31.7 | 52.0 | 11.8 | 2.2 | 0.13 | 82500 |
| | | | | 14.0 | | | |
| THREE-TROUGH GaAs PLANAR-SOLID STATE (5.22 GW UTIL) | 58 | 35.0 | 56.0 | 15.0 | 2.8 | 0.14 | 83400 |
| | | | | 17.8 | | | |
| DUAL REFLECTORS GaAs-SANDWICH (2.42 GW UTIL) | 125 | 32.7 | 57.3 | 7.4 | 1.5 | 0.08 | 83680 |
| | | | | 8.9 | | | |
| DUAL REFLECTORS FBG-SANDWICH (3.06 GW UTIL) | 98 | 32.8 | 55.7 | 7.8 | 1.3 | 0.08 | 82975 |
| | | | | 9.1 | | | |

Cost estimates have been based on technical characteristics and design definitions developed during the study. A summary of DDT&E and first unit costs are presented in Table B-4 for space and ground segments of the reference SPS configuration. These same elements of the program are listed in Table B-5 as they apply to the investment per SPS.

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE B-4 SATELLITE POWER SYSTEM (SPS) PROGRAM DEVELOPMENT COST

| WBS # | DESCRIPTION | DDT&E | DEVELOPMENT T&U | TOTAL |
|-------|--------------------------------------|-----------|-----------------|-----------|
| I | SATELLITE POWER SYSTEM (SPS) PROGRAM | 33589.491 | 53646.430 | 87236.062 |
| 1.1 | SATELLITE SYSTEM | 7799.059 | 9811.328 | 17610.387 |
| 1.2 | SPACE CONSTRUCTION & SUPPORT | 8564.035 | 10757.824 | 19321.859 |
| 1.3 | TRANSPORTATION | 13154.137 | 23336.477 | 36480.613 |
| 1.4 | GROUND RECEIVING STATION | 135.368 | 4249.754 | 4385.121 |
| 1.5 | MANAGEMENT AND INTEGRATION | 1482.630 | 2407.469 | 3890.299 |
| 1.6 | MASS CONTINGENCY | 2454.463 | 3089.372 | 5539.832 |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE B-5 SATELLITE POWER SYSTEM (SPS) PROGRAM AVERAGE COST

| WBS # | DESCRIPTION | INV PER SAT | OPS COST PER SAT PER YEAR RCI | O&M TOTAL OPS |
|-------|--------------------------------------|-------------|----------------------------------|---------------|
| I | SATELLITE POWER SYSTEM (SPS) PROGRAM | 12742.617 | 145.772 | 77.249 |
| 1.1 | SATELLITE SYSTEM | 4978.184 | 33.025 | 0.720 |
| 1.2 | SPACE CONSTRUCTION & SUPPORT | 209.874 | 19.465 | 19.341 |
| 1.3 | TRANSPORTATION | 1989.518 | 78.521 | 17.419 |
| 1.4 | GROUND RECEIVING STATION | 4217.105 | 0.321 | 33.225 |
| 1.5 | MANAGEMENT AND INTEGRATION | 569.734 | 6.567 | 3.939 |
| 1.6 | MASS CONTINGENCY | 778.208 | 7.874 | 3.009 |

As was mentioned, RCI and O&M costs have been segregated into pre-IOC and post-IOC categories. Pre-IOC tabulations were calculated on an annual basis as presented in Table B-6. The total pre-IOC value per SPS would require multiplication by 30 years. Post-IOC operations costs are presented in Table B-7 for the reference configuration on an annual basis. A summary of costs on all five SPS concepts—including pre- and post-IOC values, was shown in Table B-3.

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE B-6 SATELLITE POWER SYSTEM (SPS) PROGRAM PRE-IOC COSTS

| WBS # | DESCRIPTION | AVERAGE OPS COST PER SAT/HR INV PER SAT | PRE-IOC COST PER SAT/HR RCI-PRE | O&M-PRE | TOTAL PRE-IOC |
|-------|--------------------------------------|--|------------------------------------|---------|---------------|
| I | SATELLITE POWER SYSTEM (SPS) PROGRAM | 12742.617 | 71.944 | 6.184 | 78.048 |
| 1.1 | SATELLITE SYSTEM | 4978.184 | 0.0 | 0.0 | 0.0 |
| 1.2 | SPACE CONSTRUCTION & SUPPORT | 209.874 | 4.331 | 3.713 | 8.044 |
| 1.3 | TRANSPORTATION | 1989.518 | 63.481 | 0.0 | 63.481 |
| 1.4 | GROUND RECEIVING STATION | 4217.105 | 0.007 | 1.570 | 1.577 |
| 1.5 | MANAGEMENT AND INTEGRATION | 569.734 | 3.399 | 0.264 | 3.659 |
| 1.6 | MASS CONTINGENCY | 778.208 | 0.650 | 0.597 | 1.247 |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE B-7 SATELLITE POWER SYSTEM (SPS) PROGRAM POST-IOC COSTS¹

| NO. # | DESCRIPTION | POST-IOC COSTS | | |
|-------|--------------------------------------|----------------|-----------|----------------|
| | | RCI-POST | OP&M-POST | TOTAL POST-IOC |
| 1 | SATELLITE POWER SYSTEM (SPS) PROGRAM | 73.828 | 71.346 | 144.974 |
| 1.1 | SATELLITE SYSTEM | 33.825 | 0.720 | 33.745 |
| 1.2 | SPACE CONSTRUCTION & SUPPORT | 19.134 | 15.628 | 30.762 |
| 1.3 | TRANSPORTATION | 15.039 | 17.419 | 32.459 |
| 1.4 | GROUND RECEIVING STATION | 0.234 | 31.656 | 31.890 |
| 1.5 | MANAGEMENT AND INTEGRATION | 3.172 | 3.271 | 6.443 |
| 1.6 | MASS CONTINGENCY | 7.224 | 2.452 | 9.676 |

Relative distributions of cost for the Rockwell reference concept are shown in Figure B-4. Transportation systems dominate DDT&E and first-unit cost by contributing to over 40% of each cost estimate. However, in the case of the TFU, it is known that these costs cover system elements with a service life that is capable of building more than one SPS. Whereas, average investment costs and construction operations (RCI/O&M) dollars for the reference

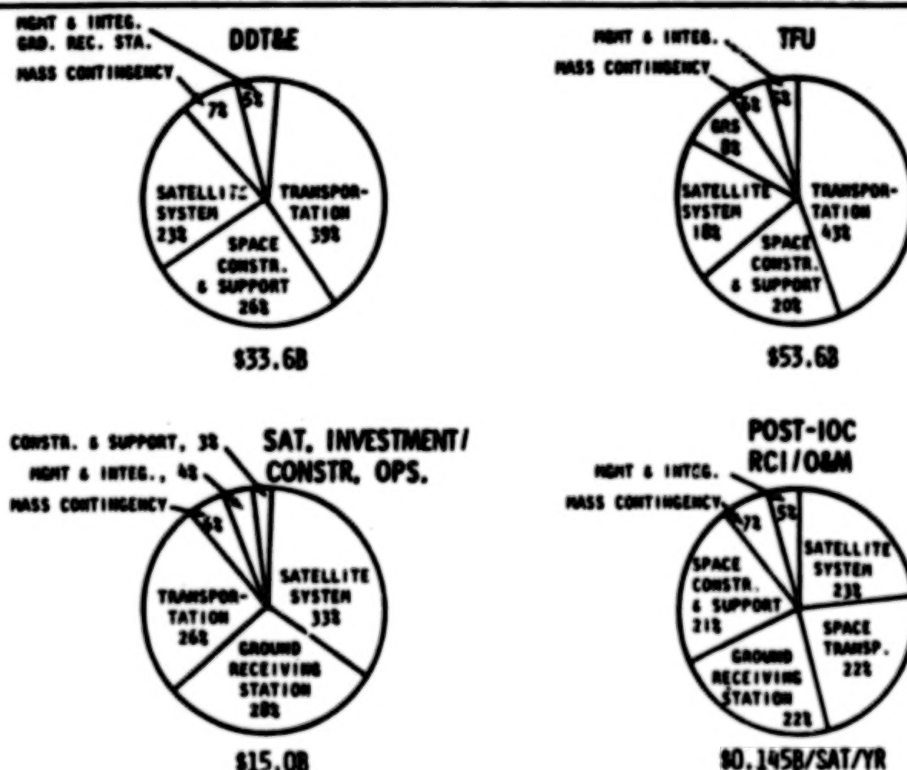


Figure B-4. Rockwell Reference Planar/Klystron Concept (1980 Exhibit D—1979 Dollars)

concept show that the satellite, GRS, and transportation system elements each comprise about 30% of the total.

B.4.1 DEVELOPMENT COST (DDT&E) AND THEORETICAL FIRST UNIT (TFU)

Total program DDT&E and TFU cost for a first full-up 5-GW SPS system is \$87.2 billion. The DDT&E of \$33.6 billion and the \$53.6 billion for the TFU are itemized by SPS WBS line item in a subsequent table. Detailed DDT&E cost breakdowns show that 65% of the DDT&E cost is identifiable to transportation and space construction/support systems.

In view of the physical size of the satellite and supportive subsystems and the large quantities required for certain parts and components, it was not considered reasonable to estimate the DDT&E costs entirely as a function of total mass, area, or power per subsystem—which is generally the method; instead, it was considered desirable to determine DDT&E costs by application of a development factor (DF). In general, the DF was applied on the basis of a particular system/component in conjunction with the engineering staff and as related to the program development scenario and the usage/availability of the system when needed. For example, the EOTV pilot plant and test article is required early in the program for SPS verification and proof of concept. This unit will be built first and DDT&E on many components will be required before items can be made available. (For example, the structure, concentrators, solar cells, power distribution, and supporting SPS systems will afford design verifications nearly identical to those of the full-up SPS satellite.) As a result, a 1.0 DF was used on components of the test article; whereas on later usages of these systems, such as on similar systems of the satellite itself, a reduced factor was applied in recognition of the completed DDT&E effort. This logic was also followed in other areas of SPS program cost analysis.

DDT&E and TFU cost breakdowns are shown in Table B-8. The TFU listing reflects a somewhat different makeup of costs when compared to the DDT&E costs. TFU estimates of \$53.6 billion include the full dollar assessment for an early pilot plant, an initial satellite and ground receiving station, space transportation fleets, the LEO, SCB, and support assembly equipment, and the facilities needed to establish a 5-GW SPS operational capability. This means that the TFU cost includes elements with a service lifetime capable of building more than one SPS system. In this regard, analysis has shown that transportation and space construction and support equipment represent the largest portion of total TFU costs. However, it is these same systems that will be used to construct additional satellites.

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
 TABLE B-8. SATELLITE POWER SYSTEM (SPS) PROGRAM DEVELOPMENT COST

| WBS # | DESCRIPTION | DDT&E | DEVELOPMENT 1FU | TOTAL |
|-----------|--------------------------------------|-----------|--------------------|-----------|
| 1 | SATELLITE POWER SYSTEM (SPS) PROGRAM | 33589.691 | 53646.430 | 87236.062 |
| 1.1 | SATELLITE SYSTEM | 7799.059 | 9611.328 | 17610.387 |
| 1.1.1 | ENERGY CONVERSION - SATELLITE | 137.259 | 2554.026 | 2691.285 |
| 1.1.1.1 | STRUCTURE | 82.870 | 213.410 | 296.280 |
| 1.1.1.1.1 | PRIMARY STRUCTURE | 55.568 | 54.288 | 109.856 |
| 1.1.1.1.2 | SECONDARY STRUCTURE | 19.906 | 154.716 | 174.622 |
| 1.1.1.1.3 | MECHANISMS | 7.396 | 4.406 | 11.802 |
| 1.1.1.2 | CONCENTRATORS | 0.0 | 93.066 | 93.066 |
| 1.1.1.3 | SOLAR BLANKETS | 20.254 | 2035.508 | 2055.762 |
| 1.1.1.4 | POWER DIST. & CONDITIONING | 34.135 | 150.382 | 184.517 |
| 1.1.1.4.1 | SWITCH GEAR & REGULATORS - E.C. | 3.873 | 106.978 | 110.851 |
| 1.1.1.4.2 | LO-VOLTAGE CONVERTERS - E.C. | 1.362 | 4.202 | 5.563 |
| 1.1.1.4.3 | CONDUCTORS & INSULATION | 7.320 | 11.209 | 18.528 |
| 1.1.1.4.4 | SLIP RINGS | 8.648 | 25.999 | 34.648 |
| 1.1.1.4.5 | BATTERIES | 6.511 | 0.317 | 6.829 |
| 1.1.1.4.6 | BATTERY PDCC | 6.421 | 1.677 | 8.098 |
| 1.1.1.5 | THERMAL CONTROL | 0.0 | 0.0 | 0.0 |
| 1.1.1.6 | MAINTENANCE | 0.0 | 61.660 | 61.660 |
| 1.1.1.6.1 | MAINTENANCE - FREE FLYERS | 0.0 | 34.279 | 34.279 |
| 1.1.1.6.2 | MANNED MANIPULATOR | 0.0 | 22.467 | 22.467 |
| 1.1.1.6.3 | TRACKS & ACCESS WAYS | 0.0 | 4.914 | 4.914 |
| 1.1.2 | POWER TRANSMISSION - SATELLITE | 1041.111 | 2568.322 | 3609.432 |
| 1.1.2.1 | STRUCTURE | 36.067 | 215.729 | 251.796 |
| 1.1.2.1.1 | PRIMARY STRUCTURE | 3.632 | 1.345 | 4.977 |
| 1.1.2.1.2 | SECONDARY STRUCTURE | 23.561 | 213.118 | 236.679 |
| 1.1.2.1.3 | MECHANISMS (TRUNNIONS) | 8.874 | 1.266 | 10.140 |
| 1.1.2.2 | TRANSMITTER SUBARAYS - KLYSTRONS | 129.306 | 1580.665 | 1709.971 |
| 1.1.2.2.1 | KLYSTRON MP1 & RS OUTGE | 129.306 | 0.0 | 129.306 |
| 1.1.2.2.2 | WAVE GUIDE | 0.0 | 38.639 | 38.639 |
| 1.1.2.2.3 | HEAT PIPES -THERMAL | 0.0 | 333.757 | 333.757 |
| 1.1.2.2.4 | KLYSTRON POWER MODULE ELEMENT | 0.0 | 304.621 | 304.621 |
| 1.1.2.2.5 | PHASE SHIFTERS | 0.0 | 166.307 | 166.307 |
| 1.1.2.2.6 | PHASE CONTROL ELECTRONICS | 0.0 | 144.703 | 144.703 |
| 1.1.2.2.7 | POWER DIVIDERS & COMBINERS | 0.0 | 23.031 | 23.031 |
| 1.1.2.2.8 | MW SYSTEM INTEGRATION | 0.0 | 569.608 | 569.608 |

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ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE B-8. SATELLITE POWER SYSTEM (SPS) PROGRAM DEVELOPMENT COST

| WBS # | DESCRIPTION | DDTCE | DEVELOPMENT TFU | TOTAL |
|-----------|--|---------|--------------------|---------|
| 1.1.2.3 | POWER DIST. & CONDITIONING | 26.852 | 471.514 | 498.366 |
| 1.1.2.3.1 | SWITCH GEAR & REGULATORS | 4.014 | 108.028 | 112.042 |
| 1.1.2.3.2 | HI-VOLTAGE CONVERTERS | 7.382 | 310.012 | 317.395 |
| 1.1.2.3.3 | LO-VOLTAGE CONVERTERS | 2.392 | 1.338 | 3.730 |
| 1.1.2.3.4 | CONDUCTORS & INSULATION | 5.232 | 3.618 | 8.849 |
| 1.1.2.3.5 | BATTERIES | 0.0 | 14.901 | 14.901 |
| 1.1.2.3.6 | BATTERY PGC | 7.832 | 33.618 | 41.450 |
| 1.1.2.4 | THERMAL CONTROL - INSULATION | 14.174 | 170.118 | 184.292 |
| 1.1.2.5 | CONTROL - PHASE REFERENCE | 0.901 | 51.328 | 52.229 |
| 1.1.2.5.1 | REFERENCE FREQUENCY GENERATOR | 0.117 | 0.117 | 0.234 |
| 1.1.2.5.2 | DIST. SYSTEM, COAXIAL CABLE | 0.702 | 42.120 | 42.822 |
| 1.1.2.5.3 | DIST. SYSTEM, DEVICES | 0.082 | 9.091 | 9.173 |
| 1.1.2.6 | MAINTENANCE | 833.812 | 78.967 | 912.779 |
| 1.1.2.6.1 | MAINTENANCE - FREE FLYERS | 0.0 | 42.551 | 42.551 |
| 1.1.2.6.2 | GANTRY CRANE | 106.540 | 0.257 | 106.797 |
| 1.1.2.6.3 | UN-CRANE CONTROL CENTER | 727.272 | 35.456 | 762.728 |
| 1.1.2.6.4 | TRACKS & ACCESS WAYS | 0.0 | 0.702 | 0.702 |
| 1.1.3 | INFORMATION MGMT. & CONTROL - SATELLITE | 97.615 | 229.787 | 327.402 |
| 1.1.3.1 | MASTER CONTROL COMPUTER | 18.864 | 9.179 | 28.048 |
| 1.1.3.2 | DISPLAYS & CONTROLS | 12.572 | 1.417 | 13.989 |
| 1.1.3.3 | SUPERVISORY COMPUTER | 3.221 | 2.721 | 5.941 |
| 1.1.3.4 | REMOTE COMPUTER | 3.093 | 6.664 | 9.757 |
| 1.1.3.5 | BUS CONTROL UNIT | 3.672 | 8.119 | 11.792 |
| 1.1.3.6 | MICROPROCESSORS | 3.750 | 7.910 | 11.659 |
| 1.1.3.7 | REMOTE ACQUISITION & CONTROL | 3.668 | 8.716 | 12.384 |
| 1.1.3.8 | SUBMULTIPLEXORS | 2.356 | 77.359 | 79.715 |
| 1.1.3.9 | INSTRUMENTATION | 33.813 | 89.513 | 123.326 |
| 1.1.3.10 | OPTICAL FIBER | 0.945 | 0.742 | 1.687 |
| 1.1.3.11 | CABLES/HARNESS | 11.657 | 17.447 | 29.104 |
| 1.1.4 | ATTITUDE CONTROL & STATIONKEEPING -SATELLITE | 15.192 | 81.259 | 96.451 |
| 1.1.4.1 | ACS HARDWARE | 15.192 | 81.259 | 96.451 |
| 1.1.4.1.1 | ACS THRUSTER COMPONENTS | 6.635 | 79.004 | 85.638 |
| 1.1.4.1.2 | ACS - CONDUCTORS & INSULATION | 0.892 | 0.009 | 0.901 |
| 1.1.4.1.3 | ACS - POWER PROCESSING EQUIPMENT | 1.438 | 0.936 | 2.374 |
| 1.1.4.1.4 | ACS - THRUSTER GIMBALS AND MOUNTING | 6.227 | 1.310 | 7.538 |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE B-8. SATELLITE POWER SYSTEM (SPS) PROGRAM DEVELOPMENT COST

| WDS # | DESCRIPTION | DEVELOPMENT | | TOTAL |
|------------|--------------------------------------|-------------|----------|----------|
| | | DOT&E | TFU | |
| 1.1.4.2 | ACSS PROPELLANT | 0.0 | 0.0 | 0.0 |
| 1.1.5 | COMMUNICATIONS - SATELLITE | 0.0 | 0.0 | 0.0 |
| 1.1.5.1 | SATELLITE TO GROUND | 0.0 | 0.0 | 0.0 |
| 1.1.5.2 | SATELLITE TO RESUPPLY VEHICLES | 0.0 | 0.0 | 0.0 |
| 1.1.5.3 | SATELLITE INTERCOM | 0.0 | 0.0 | 0.0 |
| 1.1.6 | INTERFACE - SATELLITE | 29.711 | 74.002 | 103.713 |
| 1.1.6.1 | STRUCTURE | 16.792 | 17.709 | 34.501 |
| 1.1.6.1.1 | PRIMARY STRUCTURE | 8.645 | 7.956 | 16.601 |
| 1.1.6.1.2 | SECONDARY STRUCTURE | 8.147 | 9.753 | 17.900 |
| 1.1.6.2 | MECHANISMS - INTERFACE | 8.043 | 19.337 | 27.380 |
| 1.1.6.3 | POWER DISTRIBUTION | 4.876 | 4.276 | 9.152 |
| 1.1.6.3.1 | CONDUCTOR & INSULATION | 3.832 | 1.268 | 5.100 |
| 1.1.6.3.2 | SLIP RING BRUSHES | 1.044 | 3.008 | 4.052 |
| 1.1.6.4 | THERMAL CONTROL | 0.0 | 0.0 | 0.0 |
| 1.1.6.5 | MAINTENANCE | 0.0 | 32.680 | 32.680 |
| 1.1.6.5.1 | MAINTENANCE - FREE FLYERS | 0.0 | 8.810 | 8.810 |
| 1.1.6.5.2 | MANNED MANIPULATOR | 0.0 | 22.467 | 22.467 |
| 1.1.6.5.3 | TRACKS & ACCESS WAYS | 0.0 | 1.404 | 1.404 |
| 1.1.7 | SYSTEMS TEST - SATELLITE | 4978.194 | 0.0 | 4978.194 |
| 1.1.7.1 | SYSTEM GROUND TEST HARDWARE | 2489.092 | 0.0 | 2489.092 |
| 1.1.7.2 | SYSTEM GROUND TEST OPERATIONS | 2489.092 | 0.0 | 2489.092 |
| 1.1.8 | GROUND SUPPORT EQUIPMENT - SATELLITE | 629.907 | 0.0 | 629.907 |
| 1.1.9 | PROOF-OF-CONCEPT PILOT PLANT | 870.085 | 4303.941 | 5174.023 |
| 1.1.9.1 | COTV PRECURSOR VEHICLE | 870.085 | 1077.751 | 1947.836 |
| 1.1.9.1.1 | PRIMARY STRUCTURE - E.C. | 75.736 | 2.398 | 78.137 |
| 1.1.9.1.2 | SECONDARY STRUCTURE - E.C. | 27.346 | 60.315 | 87.662 |
| 1.1.9.1.3 | MECHANISMS - PRECURSOR E.C. | 21.261 | 10.600 | 31.860 |
| 1.1.9.1.4 | CONCENTRATOR - E.C. | 9.254 | 3.329 | 12.583 |
| 1.1.9.1.5 | SOLAR BLANKET - E.C. | 67.440 | 89.271 | 156.711 |
| 1.1.9.1.6 | SWITCHGEAR & REGULATORS - E.C. | 5.205 | 6.809 | 12.014 |
| 1.1.9.1.7 | LOW-VOLTAGE CONVERTERS - E.C. | 1.854 | 0.211 | 2.064 |
| 1.1.9.1.8 | CONDUCTORS & INSULATION - E.C. | 7.492 | 1.212 | 8.704 |
| 1.1.9.1.9 | ACS HARDWARE - E.C. | 11.893 | 344.323 | 356.216 |
| 1.1.9.1.10 | ACS - CONDUCTORS & INSUL - E.C. | 2.439 | 0.030 | 2.469 |
| 1.1.9.1.11 | ACS - BATTERIES - E.C. | 7.839 | 49.789 | 57.627 |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE B-8. SATELLITE POWER SYSTEM (SPS) PROGRAM DEVELOPMENT COST

| WBS # | DESCRIPTION | DDTCE | DEVELOPMENT TFU | TOTAL |
|------------|---|---------|--------------------|---------|
| 1.1.9.1.12 | ACS - BATTERY PDEC - E.C. | 14.514 | 11.954 | 26.469 |
| 1.1.9.1.13 | SLIPRINGS - PRECURSOR E.C. | 26.862 | 1.926 | 28.788 |
| 1.1.9.1.14 | TRACS & ACCESS WAYS - E.C. | 0.0 | 2.047 | 2.047 |
| 1.1.9.1.15 | PRIMARY STRUCTURE - INTERFACE | 197.661 | 7.956 | 205.617 |
| 1.1.9.1.16 | SECONDARY STRUCTURE - INTERFACE | 8.734 | 6.462 | 15.196 |
| 1.1.9.1.17 | MECHANISMS - INTERFACE | 17.193 | 31.176 | 48.369 |
| 1.1.9.1.18 | CONDUCTORS & INSULATION - INTERFACE | 2.807 | 0.044 | 2.851 |
| 1.1.9.1.19 | SLIPRING BRUSHES - PRECURSOR - INTERFACE | 1.171 | 0.117 | 1.288 |
| 1.1.9.1.20 | PRIMARY STRUCTURE - POWER TRANS | 22.915 | 1.345 | 24.260 |
| 1.1.9.1.21 | SECONDARY STRUCTURE - POWER TRANS | 19.845 | 32.204 | 52.049 |
| 1.1.9.1.22 | MECHANISMS - POWER TRANS. | 13.312 | 1.899 | 15.210 |
| 1.1.9.1.23 | P.T. KLYSTRON SUBARRAY DUTEE | 91.513 | 0.0 | 91.513 |
| 1.1.9.1.24 | P.T. KLYSTRON WAVEGUIDE | 0.0 | 2.192 | 2.192 |
| 1.1.9.1.25 | P.T. KLYSTRON HEATPIPER | 0.0 | 18.938 | 18.938 |
| 1.1.9.1.26 | P.T. KLYSTRON P.M. ELEMENT | 0.0 | 14.742 | 14.742 |
| 1.1.9.1.27 | P.T. KLYSTRON PHASE SHIFTERS | 0.0 | 7.371 | 7.371 |
| 1.1.9.1.28 | P. T. KLYSTRON PH. CONTROL ELECTRONICS | 0.0 | 6.016 | 6.016 |
| 1.1.9.1.29 | P. T. KLYSTRON POWER DIVIDERS AND COMBINERS | 0.0 | 0.958 | 0.958 |
| 1.1.9.1.30 | KLYSTRON SUBARRAY SYSTEM INTEGRATION | 0.0 | 20.926 | 20.926 |
| 1.1.9.1.31 | PDEC - SW. GR. & REGULATORS - P.T. | 6.159 | 8.003 | 14.162 |
| 1.1.9.1.32 | PDEC - HI VOLTAGE CONVERT - P.T. | 8.163 | 16.287 | 24.470 |
| 1.1.9.1.33 | PDEC - LO VOLTAGE CONVERT - P.T. | 1.336 | 0.070 | 1.408 |
| 1.1.9.1.34 | PDEC CONDUCTORS & INSULATION - P. T. | 3.777 | 0.121 | 3.897 |
| 1.1.9.1.35 | BATTERIES - P.T. PRECURSOR | 31.793 | 14.974 | 46.767 |
| 1.1.9.1.36 | P.T. - BATTERY FUEL | 5.265 | 9.564 | 14.828 |
| 1.1.9.1.37 | THERMAL CONTROL - INSULATION - PRECURSOR R.T. | 33.170 | 58.742 | 91.912 |
| 1.1.9.1.38 | REFERENCE FREQUENCY GENERATOR - PRECURSOR | 0.585 | 0.117 | 0.702 |
| 1.1.9.1.39 | DIST. SYSTEM, COAXIAL CABLE | 0.302 | 0.605 | 0.907 |
| 1.1.9.1.40 | DIST. SYSTEM DEVICES | 0.026 | 0.585 | 0.611 |
| 1.1.9.1.41 | P.T. - MASTER CONTROL COMPUTER - IMS/COM | 27.076 | 11.186 | 38.263 |
| 1.1.9.1.42 | P.T. BUS CONTROL UNIT | 10.898 | 6.727 | 17.625 |
| 1.1.9.1.43 | P.T. - MICROPROCESSORS - IMS/COM | 9.763 | 5.936 | 15.699 |
| 1.1.9.1.44 | P.T. - REMOTE ACW & CONTROL - IMS/COM | 1.588 | 7.519 | 9.107 |
| 1.1.9.1.45 | P.T. - SUMMULTIPLEXER - IMS/COM | 4.744 | 163.751 | 168.495 |
| 1.1.9.1.46 | P.T. - INSTRUMENTATION - IMS/COM | 1.170 | 4.680 | 5.850 |

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TABLE B-8. SATELLITE POWER SYSTEM (SPS) PROGRAM DEVELOPMENT COST

| WBS # | DESCRIPTION | DEVELOPMENT | | TOTAL |
|------------|---|-------------|-----------|-----------|
| | | DDTCE | TFU | |
| 1.1.9.1.47 | P.T. - CABLES & HARNESS - IMS/COM | 4.350 | 0.744 | 5.094 |
| 1.1.9.1.48 | P.T. TRACKS AND ACCESSWAYS FOR MW ANT | 28.342 | 0.702 | 29.044 |
| 1.1.9.1.49 | P.T. ANT. MW LIFTS - INSTALL & C/O EQUIP. | 37.272 | 30.881 | 68.153 |
| 1.1.9.2 | PRECURSOR OPERATIONS | 0.0 | 3221.191 | 3221.191 |
| 1.1.9.2.1 | PRECURSOR STS TRANSPORTATION | 0.0 | 3213.010 | 3213.010 |
| 1.1.9.2.2 | PRECURSOR CONSTRUCTION CREW | 0.0 | 6.571 | 6.571 |
| 1.1.9.2.3 | PRECURSOR GEU TEST ACTIVITY | 0.0 | 0.600 | 0.600 |
| 1.1.9.2.4 | PRECURSOR PROPELLANT | 0.0 | 1.011 | 1.011 |
| 1.1.9.3 | PRECURSOR GROUND RECEIVING FACILITY | 0.0 | 5.000 | 5.000 |
| 1.2 | SPACE CONSTRUCTION & SUPPORT | 8564.035 | 10757.824 | 19321.859 |
| 1.2.1 | CONSTRUCTION FACILITIES | 4260.855 | 7827.523 | 12088.379 |
| 1.2.1.1 | WORK SUPPORT FACILITIES | 3604.684 | 4662.012 | 8266.695 |
| 1.2.1.1.1 | BEAM MACHINE | 2.340 | 118.220 | 120.560 |
| 1.2.1.1.2 | BEAM MACHINE CASSETTES SET | 0.936 | 7.389 | 8.325 |
| 1.2.1.1.3 | CABLE ATTACHMENT MACHINE | 5.031 | 35.576 | 40.607 |
| 1.2.1.1.4 | REMOTE MANIPULATOR | 4.025 | 65.929 | 69.954 |
| 1.2.1.1.5 | BLANKET DISPENSER MACHINE | 4.600 | 33.076 | 37.756 |
| 1.2.1.1.6 | SOLAR BLANKET CASSETTES | 1.170 | 22.815 | 23.985 |
| 1.2.1.1.7 | REFLECTOR DISPENSER MACHINE | 7.020 | 5.442 | 12.462 |
| 1.2.1.1.8 | REFLECTOR CASSETTES | 1.170 | 3.184 | 4.354 |
| 1.2.1.1.9 | CABLE/LATENCY DISPENSER MACHINES | 2.574 | 26.660 | 29.234 |
| 1.2.1.1.10 | ANTENNA PANEL INS. EQUIP. | 93.600 | 234.318 | 327.918 |
| 1.2.1.1.11 | GANYTRY/Cranes | 15.912 | 99.490 | 115.402 |
| 1.2.1.1.12 | CARGO STORAGE DEPUTS | 4.327 | 8.844 | 13.231 |
| 1.2.1.1.13 | FAB FIXTURE | 2533.200 | 96.461 | 2629.660 |
| 1.2.1.1.14 | AIRLOCK DOCKING MODULE (ADM) | 0.0 | 283.493 | 283.493 |
| 1.2.1.1.15 | BASE MGMT. MODULE (BMM) | 0.0 | 1420.228 | 1420.228 |
| 1.2.1.1.16 | POWER MODULE (PM) | 0.0 | 1258.288 | 1258.288 |
| 1.2.1.1.17 | PRESSURIZED STORAGE MODULE (PSM) | 928.641 | 942.614 | 1871.260 |
| 1.2.1.2 | CREW SUPPORT FACILITIES-SCB | 656.174 | 3030.639 | 3686.813 |
| 1.2.1.2.1 | AIRLOCK DOCKING MODULE-ADM | 36.448 | 85.893 | 122.341 |
| 1.2.1.2.2 | CREW HABITABILITY MODULE-CHM | 0.0 | 1912.313 | 1912.313 |
| 1.2.1.2.3 | CONSUMABLES LOGISTICS MODULE-CLM | 0.0 | 707.469 | 707.469 |
| 1.2.1.2.4 | SHIELDING | 401.544 | 24.757 | 426.301 |
| 1.2.1.2.5 | CREW SUPPORT MODULE-CSM | 218.182 | 300.206 | 518.388 |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE B-8. SATELLITE POWER SYSTEM (SPS) PROGRAM DEVELOPMENT COST

| NBS # | DESCRIPTION | DOT&E | DEVELOPMENT TFU | TOTAL |
|-----------|---------------------------------------|-----------|--------------------|-----------|
| 1.2.1.3 | OPERATIONS | 0.0 | 134.873 | 134.873 |
| 1.2.1.3.1 | OPERATIONS, CONSTRUCTION CREW | 0.0 | 92.574 | 92.574 |
| 1.2.1.3.2 | ORBITAL OPERATIONS, CONST. PROV. | 0.0 | 42.299 | 42.299 |
| 1.2.2 | LOGISTICS SUPPORT FACILITIES-LEO | 4303.180 | 1091.385 | 5394.562 |
| 1.2.2.1 | WORK SUPPORT FACILITIES | 3293.540 | 703.519 | 3997.058 |
| 1.2.2.1.1 | BASE MGMT. MODULE-BMM | 2884.040 | 363.652 | 3247.693 |
| 1.2.2.1.2 | POWER MODULE-PM | 409.500 | 322.187 | 731.687 |
| 1.2.2.1.3 | AIRLOCK DOCKING MODULE - ADM | 0.0 | 17.679 | 17.679 |
| 1.2.2.2 | CREW SUPPORT FACILITIES | 1009.642 | 384.675 | 1394.317 |
| 1.2.2.2.1 | CREW HABITABILITY MODULE-CHM | 306.865 | 119.256 | 426.121 |
| 1.2.2.2.2 | CONSUMABLES LOGISTICS MODULE CLM | 310.050 | 82.011 | 392.061 |
| 1.2.2.2.3 | CREW SUPPORT MODULE/EVA | 392.727 | 183.408 | 576.135 |
| 1.2.2.3 | OPERATIONS | 0.0 | 3.191 | 3.191 |
| 1.2.2.3.1 | LEO OPERATIONS CREW | 0.0 | 2.190 | 2.190 |
| 1.2.2.3.2 | LEO CREW PROVISIONS | 0.0 | 1.001 | 1.001 |
| 1.2.3 | UEM SUPPORT FACILITIES - SATELLITE | 0.0 | 1836.918 | 1836.918 |
| 1.2.3.1 | WORK SUPPORT FACILITIES | 0.0 | 1633.609 | 1633.609 |
| 1.2.3.1.1 | AIRLOCK DOCKING MODULE-ADM | 0.0 | 34.987 | 34.987 |
| 1.2.3.1.2 | BASE MGMT MODULE-BMM | 0.0 | 715.661 | 715.661 |
| 1.2.3.1.3 | PRESSURIZED STORAGE MODULE-PSM | 0.0 | 241.360 | 241.360 |
| 1.2.3.1.4 | POWER MODULE-PM | 0.0 | 637.602 | 637.602 |
| 1.2.3.2 | CREW SUPPORT FACILITIES | 0.0 | 201.268 | 201.268 |
| 1.2.3.2.1 | CREW HABITABILITY MODULE-CHM | 0.0 | 119.256 | 119.256 |
| 1.2.3.2.2 | CONSUMABLES LOGISTICS MODULE-CLM | 0.0 | 82.011 | 82.011 |
| 1.2.3.3 | OPERATIONS | 0.0 | 4.042 | 4.042 |
| 1.2.3.3.1 | SATELLITE OPERATIONS CREW - SCH | 0.0 | 0.584 | 0.584 |
| 1.2.3.3.2 | SATELLITE OPERATIONS CREW - MMH | 0.0 | 2.190 | 2.190 |
| 1.2.3.3.3 | CREW PROVISIONS - SCH | 0.0 | 0.267 | 0.267 |
| 1.2.3.3.4 | UEM CREW PROVISIONS - MMH | 0.0 | 1.001 | 1.001 |
| 1.3 | TRANSPORTATION | 13154.137 | 23334.477 | 36488.613 |
| 1.3.1 | SPS-HEAVY LIFT LAUNCH VEHICLE (HLLV) | 10062.000 | 11632.133 | 21694.133 |
| 1.3.1.1 | SPS-HLLV FLEET | 10062.000 | 10921.242 | 20983.242 |
| 1.3.1.2 | SPS-HLLV OPERATIONS (VTO-HL) | 0.0 | 710.892 | 710.892 |
| 1.3.2 | CARGO ORBITAL TRANSFER VEHICLE (COTV) | 128.530 | 4578.930 | 4707.457 |
| 1.3.2.1 | COTV VEHICLES | 128.530 | 4571.391 | 4699.918 |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE B-8. SATELLITE POWER SYSTEM (SPS) PROGRAM DEVELOPMENT COST

| WBS # | DESCRIPTION | DDTCE | DEVELOPMENT TFU | TOTAL |
|------------|---|----------|--------------------|----------|
| 1.3.2.1.1 | PRIMARY STRUCTURE | 12.004 | 14.391 | 26.395 |
| 1.3.2.1.2 | SECONDARY STRUCTURE | 12.015 | 320.645 | 332.659 |
| 1.3.2.1.3 | MECHANISMS - EOTV | 8.409 | 25.440 | 33.849 |
| 1.3.2.1.4 | TRACKS AND ACCESSWAYS | 0.0 | 1.053 | 1.053 |
| 1.3.2.1.5 | CONCENTRATOR | 1.981 | 18.716 | 20.697 |
| 1.3.2.1.6 | SOLAR BLANKET | 39.056 | 499.988 | 539.046 |
| 1.3.2.1.7 | SWITCHGEAR AND REGULATORS | 2.781 | 13.407 | 16.188 |
| 1.3.2.1.8 | LO-VOLTAGE CONVERTERS | 1.207 | 1.011 | 2.218 |
| 1.3.2.1.9 | CONDUCTORS AND INSULATION | 3.807 | 7.441 | 11.248 |
| 1.3.2.1.10 | BATTERIES | 4.310 | 1707.046 | 1711.356 |
| 1.3.2.1.11 | BATTERY PDC | 6.421 | 71.727 | 78.148 |
| 1.3.2.1.12 | ACS HARDWARE-CUTV | 9.461 | 1756.297 | 1765.758 |
| 1.3.2.1.13 | INFO. MGMT. AND CONTROL | 27.076 | 134.238 | 161.314 |
| 1.3.2.2 | CUTV OPERATIONS | 0.0 | 7.541 | 7.541 |
| 1.3.3 | STS PERSONNEL CARGO LAUNCH VEHICLE | 286.650 | 3022.765 | 3309.415 |
| 1.3.3.1 | STS CARGO CARRIER AND EM | 286.650 | 607.795 | 894.445 |
| 1.3.3.2 | STS OPERATIONS - GROWTH AND DERIVATIVE HLLV | 0.0 | 2414.970 | 2414.970 |
| 1.3.3.2.1 | OPERATIONS-STS GROWTH HLLV | 0.0 | 1458.000 | 1458.000 |
| 1.3.3.2.2 | OPERATIONS - STS DERIVATIVE | 0.0 | 956.97 | 956.970 |
| 1.3.4 | PERSONNEL ORBITAL TRANS VEHICLE | 409.500 | 67.937 | 477.437 |
| 1.3.4.1 | PUTV-FLEET | 409.500 | 66.328 | 475.828 |
| 1.3.4.2 | PUTV-OPERATIONS | 0.0 | 1.609 | 1.609 |
| 1.3.5 | PERSONNEL MODULE (PM) | 138.060 | 287.814 | 425.874 |
| 1.3.5.1 | PM FLEET | 138.060 | 284.830 | 422.890 |
| 1.3.5.2 | PM OPERATIONS | 0.0 | 2.983 | 2.983 |
| 1.3.6 | INTRAORBITAL TRANSFER VEHICLE (IOTV) | 117.000 | 6.753 | 123.753 |
| 1.3.6.1 | IOTV FLEET | 117.000 | 6.633 | 123.633 |
| 1.3.6.2 | IOTV OPERATIONS | 0.0 | 0.120 | 0.120 |
| 1.3.7 | GROUND SUPPORT FACILITIES | 2012.400 | 3738.150 | 5750.547 |
| 1.3.7.1 | LAUNCH FACILITIES | 0.0 | 0.0 | 0.0 |
| 1.3.7.2 | RECOVERY FACILITIES | 0.0 | 0.0 | 0.0 |
| 1.3.7.3 | FUEL FACILITIES | 0.0 | 0.0 | 0.0 |
| 1.3.7.4 | LOGISTICS SUPPORT | 0.0 | 0.0 | 0.0 |
| 1.3.7.5 | OPERATIONS | 0.0 | 0.0 | 0.0 |
| 1.4 | GROUND RECEIVING STATION | 135.368 | 4249.754 | 4385.121 |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE B-8. SATELLITE POWER SYSTEM (SPS) PROGRAM DEVELOPMENT COST

| WBS # | DESCRIPTION | DDT&E | DEVELOPMENT TFU | TOTAL |
|-----------|--|---------|--------------------|----------|
| 1.4.1 | SITE AND FACILITIES | 1.170 | 228.381 | 229.551 |
| 1.4.1.1 | LAND AND PREPARATION | 0.0 | 123.248 | 123.248 |
| 1.4.1.1.1 | LAND | 0.0 | 40.950 | 40.950 |
| 1.4.1.1.2 | LAND PREPARATION | 0.0 | 82.298 | 82.298 |
| 1.4.1.2 | ROADS AND FENCES | 0.0 | 86.791 | 86.791 |
| 1.4.1.2.1 | RAILS AND RUALS | 0.0 | 86.241 | 86.241 |
| 1.4.1.2.2 | FENCING | 0.0 | 0.550 | 0.550 |
| 1.4.1.3 | UTILITIES | 0.0 | 0.234 | 0.234 |
| 1.4.1.4 | BUILDINGS | 0.0 | 13.428 | 13.428 |
| 1.4.1.4.1 | STORAGE, MAINTENANCE FACILITIES | 0.0 | 1.521 | 1.521 |
| 1.4.1.4.2 | CONV. STA. & MONITOR/CONTROL FAC. | 0.0 | 11.907 | 11.907 |
| 1.4.1.5 | MAINTENANCE EQPT. FOR SITE & FACILITIES | 0.0 | 4.680 | 4.680 |
| 1.4.1.6 | LIGHTNING PROTECTION | 0.0 | 0.0 | 0.0 |
| 1.4.1.7 | SITE & FACILITIES DDTC | 1.170 | 0.0 | 1.170 |
| 1.4.2 | RECTENNA SUPPORT STRUCTURE | 2.340 | 2164.186 | 2166.526 |
| 1.4.2.1 | STEEL PANEL FAB. & INSTALLATION | 0.0 | 1985.034 | 1985.034 |
| 1.4.2.1.1 | HAT SECTIONS | 0.0 | 420.416 | 420.416 |
| 1.4.2.1.2 | WIDE FLANGES | 0.0 | 345.352 | 345.352 |
| 1.4.2.1.3 | TUBE BRACES & HARDWARE | 0.0 | 504.675 | 504.675 |
| 1.4.2.1.4 | ASSEMBLY & INSTALLATION | 0.0 | 714.591 | 714.591 |
| 1.4.2.2 | TRENCHING & CONCRETE INSTALLATION | 0.0 | 179.152 | 179.152 |
| 1.4.2.2.1 | FOOTING CONCRETE & RT-BAR | 0.0 | 82.861 | 82.861 |
| 1.4.2.2.2 | MACHINERY & EQUIPMENT - GRS CONSTRUCTION | 0.0 | 26.161 | 26.161 |
| 1.4.2.2.3 | CONSTRUCTION OPERATIONS | 0.0 | 70.130 | 70.130 |
| 1.4.2.3 | SUPPORT STRUCTURE DDTC | 2.340 | 0.0 | 2.340 |
| 1.4.3 | POWER COLLECTION | 3.510 | 1583.257 | 1586.767 |
| 1.4.3.1 | ANTENNA ARRAY ELEMENTS | 0.0 | 1318.978 | 1318.978 |
| 1.4.3.2 | POWER DISTRIBUTION SYSTEM | 0.0 | 81.502 | 81.502 |
| 1.4.3.3 | INSTALLATION & CHECKOUT | 0.0 | 182.777 | 182.777 |
| 1.4.3.4 | POWER COLLECTION-DDTC | 3.510 | 0.0 | 3.510 |
| 1.4.4 | CONTROL | 11.700 | 87.750 | 99.450 |
| 1.4.4.1 | CONTROL CENTER EQUIPMENT | 0.0 | 17.550 | 17.550 |
| 1.4.4.2 | CONTROL ELECTRONICS | 0.0 | 70.200 | 70.200 |
| 1.4.4.3 | CONTROL DDTC | 11.700 | 0.0 | 11.700 |
| 1.4.5 | GRID INTERFACE | 116.648 | 186.181 | 302.829 |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE B-8. SATELLITE POWER SYSTEM (SPS) PROGRAM DEVELOPMENT COST

| WBS # | DESCRIPTION | DDT&E | DEVELOPMENT TFU | TOTAL |
|---------|----------------------------|----------|--------------------|----------|
| 1.4.5.1 | ELECTRICAL EQUIPMENT | 0.0 | 186.181 | 186.181 |
| 1.4.5.2 | GRID INTERFALE-DDT&E | 116.648 | 0.0 | 116.648 |
| 1.4.6 | OPERATIONS | 0.0 | 0.0 | 0.0 |
| 1.4.6.1 | OPER. & MAINT. PERSONNEL | 0.0 | 0.0 | 0.0 |
| 1.4.6.2 | MAINT. MATERIAL | 0.0 | 0.0 | 0.0 |
| 1.5 | MANAGEMENT AND INTEGRATION | 1482.630 | 2407.669 | 3890.299 |
| 1.6 | MASS CONTINGENCY | 2454.463 | 3085.372 | 5539.832 |

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B.4.2 INVESTMENT AND OPERATIONS

Summarized line item costing information on the investments per SPS, including replacement capital (RCI) and operations/maintenance during construction periods preceding SPS-IOC is presented in this section. These investment costs were developed at two levels:

1. Average investment per SPS is the cost of production, assembly, installation, transportation, and testing/validation of SPS program elements including the satellite, space construction and support, transportation, and ground receiving station with an operational capability to produce electrical energy at the utility interface.
2. Replacement capital investment (RCI) and operations/maintenance (O&M) cost estimates are established on an annual basis. RCI/O&M represent capital asset replacements and major maintenance overhauls/spares that are expected to last for more than one year or result in an improvement to the operating system.

Investment per satellite is equivalent to the average cost of a total SPS requirement or option which covers all satellites and related program elements needed to establish operational systems. Although details are not included in this appendix, cost estimates were developed for five SPS concepts. Investment costs for these SPS programs are summarized in Table B-9 with reference to the SPS option quantity and power availability at the electric utility interface. RCI/O&M costs during the construction or pre-IOC period are included for various system elements.

A listing of line item costs are presented in Table B-10 itemizing estimates of the Rockwell SPS CR-2 reference (3-trough/planar/klystron) configuration (1980). This table identifies average investment cost estimates and pre-IOC replacement capital /O&M costs. RCI/O&M cost estimates are annular in this listing and should be multiplied by 30 in order to arrive at total costs associated with each SPS-WBS element. RCI/O&M estimates are listed in annular amounts to accommodate the calculation routine of the computer program and SPS option quantity requirements.

Table B-9. SPS Investment Costs (\$ $\times 10^6$)

| SPS CONCEPT | TOTAL | | SATELLITE (1.1) | | SPACE CONSTR. & SUPPORT (1.2) | | TRANSPORTATION (1.3) | | ORD. RECV. STA. (1.4) | | MGMT. & INTEG. (1.5) | | MASS CONTING. (1.6) | | SPS OPTION | GW UTIL |
|---|------------------------|-----------------------|--------------------|-------------------|-------------------------------|-------------------|----------------------|-------------------|-----------------------|-------------------|----------------------|-------------------|---------------------|-------------------|------------|---------|
| | SPS PROGRAM INVESTMENT | SPS RC1/O&M (PRE-IOC) | PROGRAM INVESTMENT | RC1/O&M (PRE-IOC) | PROGRAM INVESTMENT | RC1/O&M (PRE-IOC) | PRO-GRAM INV. | RC1/O&M (PRE-IOC) | PRO-GRAM INV. | RC1/O&M (PRE-IOC) | PRO-GRAM INV. | RC1/O&M (PRE-IOC) | PRO-GRAM INV. | RC1/O&M (PRE-IOC) | | |
| CR-2 REFERENCE CONFIG. (S-TROUGH/PLANAR/ KLYSTRON GaAs) | 12,743 | 2,341 | 4,978 | - | 210 | 241 | 1990 | 1904 | 4217 | 50 | 570 | 110 | 778 | 36 | 60 | 5.00 |
| TOTAL | 15,084 | | 4,978 | | 451 | | 3894 | | 4267 | | 680 | | 814 | | | |
| CR-2 MAGNETRON CONFIG. (S-TROUGH/PLANAR) GaAs | 11,823 | 2,231 | 3,752 | - | 225 | 314 | 1777 | 1707 | 4938 | 59 | 534 | 104 | 597 | 47 | 54 | 5.60 |
| TOTAL | 14,054 | | 3,752 | | 539 | | 3484 | | 4997 | | 636 | | 644 | | | |
| CR-2 SOLID-STATE GaAs (S-TROUGH/PLANAR/ DUAL END-MOUNTED ANT.) | 14,977 | 2,795 | 6,062 | - | 215 | 250 | 2447 | 2321 | 4643 | 55 | 668 | 131 | 942 | 38 | 58 | 5.22 |
| TOTAL | 17,772 | | 6,062 | | 465 | | 4768 | | 4698 | | 799 | | 980 | | | |
| SOLID-STATE GaAs SANDWICH CR-5 CONFIG. (DUAL REFLECTOR ANTENNAS) | 7,396 | 1,461 | 3,203 | - | 107 | 183 | 1265 | 1172 | 1996 | 11 | 329 | 68 | 496 | 27 | 125 | 2.42 |
| TOTAL | 8,857 | | 3,203 | | 290 | | 2437 | | 2007 | | 397 | | 523 | | | |
| SOLID-STATE GaAs MEG SANDWICH CR-5 (DUAL REFLECTORS/ ANTENNAS) | 7,834 | 1,331 | 3,255 | - | 137 | 214 | 1007 | 1007 | 2497 | 14 | 349 | 62 | 509 | 32 | 90 | 3.06 |
| TOTAL | 9,165 | | 3,255 | | 351 | | 2096 | | 2511 | | 411 | | 541 | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE B-10. SATELLITE POWER SYSTEM (SPS) PROGRAM PRE-IOC COSTS

| WBS # | DESCRIPTION | ****PRE-IOC **** | | | TOTAL PRE-IOC |
|-----------|--------------------------------------|------------------------|-------------------------|-------------------|------------------|
| | | AVERAGE INV PER SAT | OPS COST PER RCI-PRE | SAT/YR OEM-PRE | |
| 1 | SATELLITE POWER SYSTEM (SPS) PROGRAM | 12742.617 | 71.944 | 6.104 | 78.048 |
| 1.1 | SATELLITE SYSTEM | 4978.184 | 0.0 | 0.0 | 0.0 |
| 1.1.1 | ENERGY CONVERSION - SATELLITE | 2349.125 | 0.0 | 0.0 | 0.0 |
| 1.1.1.1 | STRUCTURE | 195.373 | 0.0 | 0.0 | 0.0 |
| 1.1.1.1.1 | PRIMARY STRUCTURE | 54.288 | 0.0 | 0.0 | 0.0 |
| 1.1.1.1.2 | SECONDARY STRUCTURE | 137.181 | 0.0 | 0.0 | 0.0 |
| 1.1.1.1.3 | MECHANISMS | 3.904 | 0.0 | 0.0 | 0.0 |
| 1.1.1.2 | CONCENTRATORS | 82.586 | 0.0 | 0.0 | 0.0 |
| 1.1.1.3 | SOLAR BLANKETS | 1916.473 | 0.0 | 0.0 | 0.0 |
| 1.1.1.4 | POWER DIST. & CONDITIONING | 105.185 | 0.0 | 0.0 | 0.0 |
| 1.1.1.4.1 | SWITCH GEAR & REGULATORS - E.C. | 75.085 | 0.0 | 0.0 | 0.0 |
| 1.1.1.4.2 | LO-VOLTAGE CONVERTERS - E.C. | 3.655 | 0.0 | 0.0 | 0.0 |
| 1.1.1.4.3 | CONDUCTORS & INSULATION | 11.204 | 0.0 | 0.0 | 0.0 |
| 1.1.1.4.4 | SLIP RINGS | 13.766 | 0.0 | 0.0 | 0.0 |
| 1.1.1.4.5 | BATTERIES | 0.223 | 0.0 | 0.0 | 0.0 |
| 1.1.1.4.6 | BATTERY PDC | 1.247 | 0.0 | 0.0 | 0.0 |
| 1.1.1.5 | THERMAL CONTROL | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.1.1.6 | MAINTENANCE | 49.509 | 0.0 | 0.0 | 0.0 |
| 1.1.1.6.1 | MAINTENANCE - FREE FLYERS | 27.006 | 0.0 | 0.0 | 0.0 |
| 1.1.1.6.2 | MANNED MANIPULATOR | 17.588 | 0.0 | 0.0 | 0.0 |
| 1.1.1.6.3 | TRACKS & ACCESS WAYS | 4.914 | 0.0 | 0.0 | 0.0 |
| 1.1.2 | POWER TRANSMISSION - SATELLITE | 2304.016 | 0.0 | 0.0 | 0.0 |
| 1.1.2.1 | STRUCTURE | 191.573 | 0.0 | 0.0 | 0.0 |
| 1.1.2.1.1 | PRIMARY STRUCTURE | 1.345 | 0.0 | 0.0 | 0.0 |
| 1.1.2.1.2 | SECONDARY STRUCTURE | 188.962 | 0.0 | 0.0 | 0.0 |
| 1.1.2.1.3 | MECHANISMS (TURNIONS) | 1.266 | 0.0 | 0.0 | 0.0 |
| 1.1.2.2 | TRANSMITTER SUBARRAYS - KLYSTRONS | 1459.600 | 0.0 | 0.0 | 0.0 |
| 1.1.2.2.1 | KLYSTRON MPT & RS DICE | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.1.2.2.2 | WAVE GUIDE | 34.293 | 0.0 | 0.0 | 0.0 |
| 1.1.2.2.3 | HEAT PIPES -THERMAL | 296.216 | 0.0 | 0.0 | 0.0 |
| 1.1.2.2.4 | KLYSTRON POWER MODULE ELEMENT | 268.920 | 0.0 | 0.0 | 0.0 |
| 1.1.2.2.5 | PHASE SHIFTERS | 144.651 | 0.0 | 0.0 | 0.0 |
| 1.1.2.2.6 | PHASE CONTROL ELECTRONICS | 125.878 | 0.0 | 0.0 | 0.0 |
| 1.1.2.2.7 | POWER DIVIDERS & COMBINERS | 20.035 | 0.0 | 0.0 | 0.0 |
| 1.1.2.2.8 | HW SYSTEM INTEGRATION | 569.607 | 0.0 | 0.0 | 0.0 |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE B-10. SATELLITE POWER SYSTEM (SPS) PROGRAM PRE-IOC COSTS

| WBS # | DESCRIPTION | *****PRE-IOC ***** | | | TOTAL PRE-IOC |
|-----------|--------------------------------------|--|---------|---------|------------------|
| | | AVERAGE OPS COST PER SAT/YR INW PER SAT | RCI-PRE | OGM-PRE | |
| 1.1.2.3 | POWER DIST. & CONDITIONING | 365.275 | 0.0 | 0.0 | 0.0 |
| 1.1.2.3.1 | SWITCH GEAR & REGULATORS | 75.807 | 0.0 | 0.0 | 0.0 |
| 1.1.2.3.2 | HIGH-VOLTAGE CONVERTERS | 269.643 | 0.0 | 0.0 | 0.0 |
| 1.1.2.3.3 | LOW-VOLTAGE CONVERTERS | 1.164 | 0.0 | 0.0 | 0.0 |
| 1.1.2.3.4 | CONDUCTORS & INSULATION | 3.618 | 0.0 | 0.0 | 0.0 |
| 1.1.2.3.5 | BATTERIES | 10.457 | 0.0 | 0.0 | 0.0 |
| 1.1.2.3.6 | BATTERY PEG | 24.587 | 0.0 | 0.0 | 0.0 |
| 1.1.2.4 | THERMAL CONTROL - INSULATION | 150.982 | 0.0 | 0.0 | 0.0 |
| 1.1.2.5 | CONTROL - PHASE REFERENCE | 51.328 | 0.0 | 0.0 | 0.0 |
| 1.1.2.5.1 | REFERENCE FREQUENCY GENERATOR | 0.117 | 0.0 | 0.0 | 0.0 |
| 1.1.2.5.2 | DIST. SYSTEM, COAXIAL CABLE | 42.120 | 0.0 | 0.0 | 0.0 |
| 1.1.2.5.3 | DIST. SYSTEM, DEVICES | 9.091 | 0.0 | 0.0 | 0.0 |
| 1.1.2.6 | MAINTENANCE | 65.259 | 0.0 | 0.0 | 0.0 |
| 1.1.2.6.1 | MAINTENANCE - FREE FLYERS | 33.245 | 0.0 | 0.0 | 0.0 |
| 1.1.2.6.2 | GANTRY CRANE | 0.257 | 0.0 | 0.0 | 0.0 |
| 1.1.2.6.3 | ON-CRANE CONTROL CENTER | 31.055 | 0.0 | 0.0 | 0.0 |
| 1.1.2.6.4 | TRACKS & ACCESS WAYS | 0.702 | 0.0 | 0.0 | 0.0 |
| 1.1.3 | INFORMATION MGMT. & CONTROL - SATELL | 189.170 | 0.0 | 0.0 | 0.0 |
| 1.1.3.1 | MASTER CONTROL COMPUTER | 3.021 | 0.0 | 0.0 | 0.0 |
| 1.1.3.2 | DISPLAYS & CONTROLS | 0.515 | 0.0 | 0.0 | 0.0 |
| 1.1.3.3 | SUPERVISORY COMPUTER | 1.109 | 0.0 | 0.0 | 0.0 |
| 1.1.3.4 | REMOTE COMPUTER | 2.560 | 0.0 | 0.0 | 0.0 |
| 1.1.3.5 | BUS CONTROL UNIT | 5.958 | 0.0 | 0.0 | 0.0 |
| 1.1.3.6 | MICROPROCESSORS | 5.604 | 0.0 | 0.0 | 0.0 |
| 1.1.3.7 | REMOTE ACQUISITION & CONTROL | 6.395 | 0.0 | 0.0 | 0.0 |
| 1.1.3.8 | SUBMULTIPLEXORS | 68.467 | 0.0 | 0.0 | 0.0 |
| 1.1.3.9 | INSTRUMENTATION | 79.222 | 0.0 | 0.0 | 0.0 |
| 1.1.3.10 | OPTICAL FIBER | 0.675 | 0.0 | 0.0 | 0.0 |
| 1.1.3.11 | CABLES/HARNESS | 15.444 | 0.0 | 0.0 | 0.0 |
| 1.1.4 | ATTITUDE CONTROL & STATIONKEEPING -S | 72.235 | 0.0 | 0.0 | 0.0 |
| 1.1.4.1 | ACS HARDWARE | 72.235 | 0.0 | 0.0 | 0.0 |
| 1.1.4.1.1 | ACS THRUSTER COMPONENTS | 69.979 | 0.0 | 0.0 | 0.0 |
| 1.1.4.1.2 | ACS - CONDUCTORS & INSULATION | 0.009 | 0.0 | 0.0 | 0.0 |
| 1.1.4.1.3 | ACS - POWER PROCESSING EQUIPMENT | 0.936 | 0.0 | 0.0 | 0.0 |
| 1.1.4.1.4 | ACS - THRUSTER GIMBALS AND MOUNTING | 1.310 | 0.0 | 0.0 | 0.0 |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE B-10. SATELLITE POWER SYSTEM (SPS) PROGRAM PRE-IOC COSTS

| WBS # | DESCRIPTION | *****PRE-IOC ***** | | | TOTAL PRE-IOC |
|------------|--------------------------------------|--|---------|---------|------------------|
| | | AVERAGE OPS COST PER SAT/YR INV PER SAT | RCI-PRE | OCM-PRE | |
| 1.1.4.2 | ACSS PROPELLANT | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.1.5 | COMMUNICATIONS - SATELLITE | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.1.5.1 | SATELLITE TO GROUND | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.1.5.2 | SATELLITE TO RESUPPLY VEHICLES | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.1.5.3 | SATELLITE INTERCOM | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.1.6 | INTERFACE - SATELLITE | 63.641 | 0.0 | 0.0 | 0.0 |
| 1.1.6.1 | STRUCTURE | 16.604 | 0.0 | 0.0 | 0.0 |
| 1.1.6.1.1 | PRIMARY STRUCTURE | 7.956 | 0.0 | 0.0 | 0.0 |
| 1.1.6.1.2 | SECONDARY STRUCTURE | 8.648 | 0.0 | 0.0 | 0.0 |
| 1.1.6.2 | MECHANISMS - INTERFACE | 17.173 | 0.0 | 0.0 | 0.0 |
| 1.1.6.3 | POWER DISTRIBUTION | 3.470 | 0.0 | 0.0 | 0.0 |
| 1.1.6.3.1 | CONDUCTOR & INSULATION | 1.268 | 0.0 | 0.0 | 0.0 |
| 1.1.6.3.2 | SLIP RING BRUSHES | 2.201 | 0.0 | 0.0 | 0.0 |
| 1.1.6.4 | THERMAL CONTROL | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.1.6.5 | MAINTENANCE | 26.394 | 0.0 | 0.0 | 0.0 |
| 1.1.6.5.1 | MAINTENANCE - FREE FLYERS | 7.437 | 0.0 | 0.0 | 0.0 |
| 1.1.6.5.2 | MANNED MANIPULATOR | 17.953 | 0.0 | 0.0 | 0.0 |
| 1.1.6.5.3 | TRACKS & ACCESSWAYS | 1.404 | 0.0 | 0.0 | 0.0 |
| 1.1.7 | SYSTEMS TEST - SATELLITE | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.1.7.1 | SYSTEM GROUND TEST HARDWARE | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.1.7.2 | SYSTEM GROUND TEST OPERATIONS | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.1.8 | GROUND SUPPORT EQUIPMENT - SATELLITE | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.1.9 | PROOF-OF-CONCEPT PILOT PLANT | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.1.9.1 | CSIV PRECURSOR VEHICLE | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.1 | PRIMARY STRUCTURE - E.C. | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.2 | SECONDARY STRUCTURE - E.C. | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.3 | MECHANISMS - PRECURSOR E.C. | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.4 | CONCENTRATOR - E.C. | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.5 | SOLAR BLANKET - E.C. | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.6 | SWITCHGEAR & REGULATORS - E.C. | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.7 | LV-VOLTAGE CONVERTERS - E.C. | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.8 | CONDUCTORS & INSULATION - E.C. | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.9 | ACS HARDWARE - E.C. | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.10 | ACS - CONDUCTORS & INSUL - E.C. | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.11 | ACS - BATTERIES - E.C. | 0.0 | 0.0 | 0.0 | 0.0 |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE B-10. SATELLITE POWER SYSTEM (SPS) PROGRAM PRE-IOC COSTS

| NBS # | DESCRIPTION | ****PRE-IOC **** | | | TOTAL PRE-IOC |
|------------|--------------------------------------|--|---------|---------|------------------|
| | | AVERAGE OPS COST PER SAT/YR INV PER SAT | RC1-PRE | OEM-PRE | |
| 1.1.9.1.12 | ACS - BATTERY PUEL - E.C. | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.13 | SLIPRINGS - PRECURSOR E.C. | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.14 | TRACKS & ACCESS WAYS - E.C. | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.15 | PRIMARY STRUCTURE - INTERFACE | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.16 | SECONDARY STRUCTURE - INTERFACE | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.17 | MECHANISMS - INTERFACE | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.18 | CONDUCTORS & INSULATION - INTERFACE | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.19 | SLIPRING BRUSHES - PRECURSOR - INTER | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.20 | PRIMARY STRUCTURE - POWER TRANS | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.21 | SECONDARY STRUCTURE - POWER TRANS | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.22 | MECHANISMS - POWER TRANS. | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.23 | P.T. KLYSTRON SUBARRAY DUTIE | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.24 | P.T. KLYSTRON WAVEGUIDE | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.25 | P.T. KLYSTRON HEATPIPER | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.26 | P.T. KLYSTRON P.M. ELEMENT | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.27 | P.T. KLYSTRON PHASE SHIFTERS | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.28 | P. T. KLYSTRON PM. CONTROL ELECTRONI | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.29 | P. T. KLYSTRON POWER DIVIDERS AND CU | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.30 | KLYSTRON SUBARRAY SYSTEM INTEGRATION | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.31 | PDEC - SW. GR. & REGULATORS - P.T. | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.32 | PDEC - HI VOLTAGE CONVERT - P.T. | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.33 | PDEL - LO VOLTAGE CONVERT - P.T. | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.34 | PDEC CONDUCTORS & INSULATION - P. T. | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.35 | BATTERIES - P.T. PRECURSOR | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.36 | P.T. - BATTERY PDEL | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.37 | THERMAL CONTROL - INSULATION - PRECU | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.38 | REFERENCE FREQUENCY GENERATOR - PREC | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.39 | DIST. SYSTEM, COAXIAL CABLE | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.40 | DIST. SYSTEM DEVICES | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.41 | P.T. - MASTER CONTROL COMPUTER - IMS | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.42 | P.T. BUS CONTROL UNIT | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.43 | P.T. - MICROPROCESSORS - IMS/COM | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.44 | P.T. - REMOTE ACW & CONTROL - IMS/CO | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.45 | P.T. - SUBMULTIPLEXER - IMS/COM | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.46 | P.T. - INSTRUMENTATION - IMS/COM | 0.0 | 0.0 | 0.0 | 0.0 |

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ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE B-10. SATELLITE POWER SYSTEM (SPS) PROGRAM PRE-IOC COSTS

| WBS # | DESCRIPTION | ****PRE-IOC **** | | | TOTAL PRE-IOC |
|------------|--------------------------------------|--|---------|---------|------------------|
| | | AVERAGE OPS COST PER SAT/YR \$M PER SAT | RCI-PRE | OEM-PRE | |
| 1.1.9.1.47 | P.T. - CABLES & HARNESS - IMS/COM | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.48 | P.T. TRACKS AND ACCESSWAYS FOR MW AN | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.49 | P.T. ANI. MW LIFTS - INSTALL & L/O E | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.1.9.2 | PRECURSOR OPERATIONS | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.1.9.2.1 | PRECURSOR STS TRANSPORTATION | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.1.9.2.2 | PRECURSOR CONSTRUCTION CREW | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.1.9.2.3 | PRECURSOR GCU TEST ACTIVITY | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.1.9.2.4 | PRECURSOR PROPELLANT | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.1.9.3 | PRECURSOR GROUND RECEIVING FACILITY | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.2 | SPACE CONSTRUCTION & SUPPORT | 209.874 | 4.331 | 3.713 | 8.044 |
| 1.2.1 | CONSTRUCTION FACILITIES | 194.241 | 3.854 | 3.713 | 7.566 |
| 1.2.1.1 | WORK SUPPORT FACILITIES | 77.186 | 2.200 | 3.713 | 5.913 |
| 1.2.1.1.1 | BEAM MACHINE | 1.970 | 0.0 | 0.811 | 0.811 |
| 1.2.1.1.2 | BEAM MACHINE CASSETTES SET | 0.227 | 0.004 | 0.116 | 0.119 |
| 1.2.1.1.3 | CABLE ATTACHMENT MACHINE | 0.593 | 0.0 | 0.228 | 0.228 |
| 1.2.1.1.4 | REMOTE MANIPULATOR | 1.078 | 0.036 | 0.360 | 0.396 |
| 1.2.1.1.5 | BLANKET DISPENSER MACHINE | 0.551 | 0.0 | 0.183 | 0.183 |
| 1.2.1.1.6 | SOLAR BLANKET CASSETTES | 0.761 | 0.025 | 0.156 | 0.181 |
| 1.2.1.1.7 | REFLECTOR DISPENSER MACHINE | 0.091 | 0.0 | 0.028 | 0.028 |
| 1.2.1.1.8 | REFLECTOR CASSETTES | 0.098 | 0.002 | 0.042 | 0.044 |
| 1.2.1.1.9 | CABLE/CATENARY DISPENSER MACHINES | 0.444 | 0.0 | 0.074 | 0.074 |
| 1.2.1.1.10 | ANTENNA PANEL INS. EQUI. | 3.905 | 0.0 | 1.170 | 1.170 |
| 1.2.1.1.11 | GANTRY/CRANES | 1.658 | 0.0 | 0.281 | 0.281 |
| 1.2.1.1.12 | CABLE STORAGE DECK | 0.147 | 0.0 | 0.023 | 0.023 |
| 1.2.1.1.13 | FAB FIXTURE | 1.608 | 0.0 | 0.241 | 0.241 |
| 1.2.1.1.14 | AIRLOCK DOCKING MODULE (ADM) | 4.638 | 0.155 | 0.0 | 0.155 |
| 1.2.1.1.15 | BASE MGMT. MODULE (BMM) | 23.303 | 0.776 | 0.0 | 0.776 |
| 1.2.1.1.16 | POWER MODULE (PM) | 20.646 | 0.688 | 0.0 | 0.688 |
| 1.2.1.1.17 | PRESSURIZED STORAGE MODULE (PSM) | 15.467 | 0.515 | 0.0 | 0.515 |
| 1.2.1.2 | CREW SUPPORT FACILITIES-SCB | 49.618 | 1.654 | 0.0 | 1.654 |
| 1.2.1.2.1 | AIRLOCK DOCKING MODULE-ADM | 1.408 | 0.047 | 0.0 | 0.047 |
| 1.2.1.2.2 | CREW HABITABILITY MODULE-CHM | 31.288 | 1.043 | 0.0 | 1.043 |
| 1.2.1.2.3 | CONSUMABLES LOGISTICS MODULE-CLM | 11.586 | 0.386 | 0.0 | 0.386 |
| 1.2.1.2.4 | SHIELDING | 0.406 | 0.014 | 0.0 | 0.014 |
| 1.2.1.2.5 | CREW SUPPORT MODULE-CSM | 4.930 | 0.164 | 0.0 | 0.164 |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE B-10. SATELLITE POWER SYSTEM (SPS) PROGRAM PRE-IOC COSTS

| MBS # | DESCRIPTION | ****PRE-IOC **** | | | TOTAL PRE-IOC |
|-----------|--------------------------------------|------------------------|---------------------|-----------------------|------------------|
| | | AVERAGE INV PER SAT | OPS COST RCI-PRE | PER SAT/YR OEM-PRE | |
| 1.2.1.3 | OPERATIONS | 67.437 | 0.0 | 0.0 | 0.0 |
| 1.2.1.3.1 | OPERATIONS, CONSTRUCTION CREW | 46.287 | 0.0 | 0.0 | 0.0 |
| 1.2.1.3.2 | ORBITAL OPERATIONS, CONST. PROV. | 21.150 | 0.0 | 0.0 | 0.0 |
| 1.2.2 | LOGISTICS SUPPORT FACILITIES-LEO | 15.633 | 0.478 | 0.0 | 0.478 |
| 1.2.2.1 | WORK SUPPORT FACILITIES | 9.282 | 0.309 | 0.0 | 0.309 |
| 1.2.2.1.1 | BASE MGMT. MODULE-BMM | 4.798 | 0.160 | 0.0 | 0.160 |
| 1.2.2.1.2 | POWER MODULE-PM | 4.251 | 0.142 | 0.0 | 0.142 |
| 1.2.2.1.3 | AIRLOCK DUCKING MODULE - ADM | 0.233 | 0.008 | 0.0 | 0.008 |
| 1.2.2.2 | CREW SUPPORT FACILITIES | 5.075 | 0.169 | 0.0 | 0.169 |
| 1.2.2.2.1 | CREW HABITABILITY MODULE-CHM | 1.573 | 0.052 | 0.0 | 0.052 |
| 1.2.2.2.2 | CONSUMABLES LOGISTICS MODULE CLM | 1.082 | 0.036 | 0.0 | 0.036 |
| 1.2.2.2.3 | CREW SUPPORT MODULE/EVA | 2.420 | 0.081 | 0.0 | 0.081 |
| 1.2.2.3 | OPERATIONS | 1.276 | 0.0 | 0.0 | 0.0 |
| 1.2.2.3.1 | LEO OPERATIONS CREW | 0.876 | 0.0 | 0.0 | 0.0 |
| 1.2.2.3.2 | LEO CREW PROVISIONS | 0.400 | 0.0 | 0.0 | 0.0 |
| 1.2.3 | OEM SUPPORT FACILITIES - SATELLITE | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.2.3.1 | WORK SUPPORT FACILITIES | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.2.3.1.1 | AIRLOCK DUCKING MODULE-ADM | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.2.3.1.2 | BASE MGMT MODULE-BMM | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.2.3.1.3 | PRESSURIZED STORAGE MODULE-PSM | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.2.3.1.4 | POWER MODULE-PM | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.2.3.2 | CREW SUPPORT FACILITIES | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.2.3.2.1 | CREW HABITABILITY MODULE-CHM | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.2.3.2.2 | CONSUMABLES LOGISTICS MODULE-CLM | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.2.3.3 | OPERATIONS | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.2.3.3.1 | SATELLITE OPERATIONS CREW - SCB | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.2.3.3.2 | SATELLITE OPERATIONS CREW - MMB | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.2.3.3.3 | CREW PROVISIONS - SCB | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.2.3.3.4 | OEM CREW PROVISIONS - MMB | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.3 | TRANSPORTATION | 1989.518 | 63.481 | 0.0 | 63.481 |
| 1.3.1 | SPS-HEAVY LIFT LAUNCH VEHICLE(HLLV) | 1662.568 | 56.480 | 0.0 | 56.480 |
| 1.3.1.1 | SPS-HLLV FLEET | 1121.661 | 56.480 | 0.0 | 56.480 |
| 1.3.1.2 | SPS-HLLV OPERATIONS (VTO-HL) | 540.906 | 0.0 | 0.0 | 0.0 |
| 1.3.2 | CARGO ORBITAL TRANSFER VEHICLE(COTV) | 204.284 | 2.938 | 0.0 | 2.938 |
| 1.3.2.1 | COTV VEHICLES | 199.257 | 2.936 | 0.0 | 2.938 |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE B-10. SATELLITE POWER SYSTEM (SPS) PROGRAM PRE-IOC COSTS

| WPS # | DESCRIPTION | *****PRE-IOC***** | | | TOTAL PRE-IOC |
|------------|--|------------------------|-------------------------|-------------------|------------------|
| | | AVERAGE INV PER SAT | OPS COST PER RCI-PRE | SAT/YR UEM-PRE | |
| 1.3.2.1.1 | PRIMARY STRUCTURE | 0.640 | 0.0 | 0.0 | 0.0 |
| 1.3.2.1.2 | SECONDARY STRUCTURE | 13.721 | 0.046 | 0.0 | 0.046 |
| 1.3.2.1.3 | MECHANISMS - EUTV | 1.131 | 0.0 | 0.0 | 0.0 |
| 1.3.2.1.4 | TRACKS AND ACCESSWAYS | 0.047 | 0.0 | 0.0 | 0.0 |
| 1.3.2.1.5 | CONCENTRATOR | 0.803 | 0.003 | 0.0 | 0.003 |
| 1.3.2.1.6 | SOLAR BLANKET | 21.810 | 0.073 | 0.0 | 0.073 |
| 1.3.2.1.7 | SWITCHGEAR AND REGULATORS | 0.542 | 0.002 | 0.0 | 0.002 |
| 1.3.2.1.8 | LU-VOLTAGE CONVERTERS | 0.045 | 0.000 | 0.0 | 0.000 |
| 1.3.2.1.9 | CONDUCTORS AND INSULATION | 0.331 | 0.0 | 0.0 | 0.0 |
| 1.3.2.1.10 | BATTERIES | 75.869 | 2.529 | 0.0 | 2.529 |
| 1.3.2.1.11 | BATTERY PDEC | 3.188 | 0.016 | 0.0 | 0.016 |
| 1.3.2.1.12 | ACS HARDWARE-CUTV | 75.166 | 0.251 | 0.0 | 0.251 |
| 1.3.2.1.13 | INFU. MGMT. AND CONTROL | 5.966 | 0.020 | 0.0 | 0.020 |
| 1.3.2.2 | CUTV OPERATIONS | 5.027 | 0.0 | 0.0 | 0.0 |
| 1.3.3 | STS PERSONNEL LARGE LAUNCH VEHICLE | 50.379 | 0.0 | 0.0 | 0.0 |
| 1.3.3.1 | STS CARGO CARRIER AND EM | 10.130 | 0.0 | 0.0 | 0.0 |
| 1.3.3.2 | STS OPERATIONS - GROWTH AND DERIVATIVE | 40.249 | 0.0 | 0.0 | 0.0 |
| 1.3.3.2.1 | OPERATIONS-STS GROWTH MLLV | 24.300 | 0.0 | 0.0 | 0.0 |
| 1.3.3.2.2 | OPERATIONS - STS DERIVATIVE | 15.949 | 0.0 | 0.0 | 0.0 |
| 1.3.4 | PERSONNEL ORBITAL TRANS VEHICLE | 3.663 | 0.190 | 0.0 | 0.190 |
| 1.3.4.1 | POTV-FLEET | 2.845 | 0.190 | 0.0 | 0.190 |
| 1.3.4.2 | POTV-OPERATIONS | 0.818 | 0.0 | 0.0 | 0.0 |
| 1.3.5 | PERSONNEL MODUL-IPM | 3.463 | 0.331 | 0.0 | 0.331 |
| 1.3.5.1 | PM FLEET | 3.307 | 0.331 | 0.0 | 0.331 |
| 1.3.5.2 | PM OPERATIONS | 0.656 | 0.0 | 0.0 | 0.0 |
| 1.3.6 | INTRAOBITAL TRANSFER VEHICLE(IOTV) | 2.354 | 0.151 | 0.0 | 0.151 |
| 1.3.6.1 | IOTV FLEET | 2.262 | 0.151 | 0.0 | 0.151 |
| 1.3.6.2 | IOTV OPERATIONS | 0.097 | 0.0 | 0.0 | 0.0 |
| 1.3.7 | GROUND SUPPORT FACILITIES | 62.302 | 3.392 | 0.0 | 3.392 |
| 1.3.7.1 | LAUNCH FACILITIES | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.3.7.2 | RECOVERY FACILITIES | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.3.7.3 | FUEL FACILITIES | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.3.7.4 | LOGISTICS SUPPORT | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.3.7.5 | OPERATIONS | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.4 | GROUND RECEIVING STATION | 4217.105 | 0.087 | 1.570 | 1.657 |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE B-10. SATELLITE POWER SYSTEM (SPS) PROGRAM PRE-IOC COSTS

| NBS # | DESCRIPTION | *****PRE-IOC ***** | | | TOTAL PRE-IOC |
|-----------|---|------------------------|---------------------|-----------------------|------------------|
| | | AVERAGE INV PER SAT | OPS COST RCI-PRE | PER SAT/YR OGM-PRE | |
| 1.4.1 | SITE AND FACILITIES | 221.053 | 0.0 | 0.0 | 0.0 |
| 1.4.1.1 | LAND AND PREPARATION | 115.969 | 0.0 | 0.0 | 0.0 |
| 1.4.1.1.1 | LAND | 40.950 | 0.0 | 0.0 | 0.0 |
| 1.4.1.1.2 | LAND PREPARATION | 75.019 | 0.0 | 0.0 | 0.0 |
| 1.4.1.2 | ROADS AND FENCES | 86.742 | 0.0 | 0.0 | 0.0 |
| 1.4.1.2.1 | RAILS AND ROADS | 86.241 | 0.0 | 0.0 | 0.0 |
| 1.4.1.2.2 | FENCING | 0.501 | 0.0 | 0.0 | 0.0 |
| 1.4.1.3 | UTILITIES | 0.234 | 0.0 | 0.0 | 0.0 |
| 1.4.1.4 | BUILDINGS | 13.428 | 0.0 | 0.0 | 0.0 |
| 1.4.1.4.1 | STORAGE, MAINTENANCE FACILITIES | 1.521 | 0.0 | 0.0 | 0.0 |
| 1.4.1.4.2 | COMM. STA. & MONITOR/CONTROL FAC. | 11.907 | 0.0 | 0.0 | 0.0 |
| 1.4.1.5 | MAINTENANCE EQPT. FOR SITE & FACILITIES | 4.680 | 0.0 | 0.0 | 0.0 |
| 1.4.1.6 | LIGHTNING PROTECTION | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.4.1.7 | SITE & FACILITIES DUTY | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.4.2 | RECTENNA SUPPORT STRUCTURE | 2138.878 | 0.087 | 1.570 | 1.657 |
| 1.4.2.1 | STEEL PANEL FAB. & INSTALLATION | 1985.017 | 0.0 | 0.0 | 0.0 |
| 1.4.2.1.1 | HAT SECTIONS | 420.412 | 0.0 | 0.0 | 0.0 |
| 1.4.2.1.2 | WIDE FLANGES | 345.349 | 0.0 | 0.0 | 0.0 |
| 1.4.2.1.3 | TUBE BRACES & HARDWARE | 504.671 | 0.0 | 0.0 | 0.0 |
| 1.4.2.1.4 | ASSEMBLY & INSTALLATION | 714.585 | 0.0 | 0.0 | 0.0 |
| 1.4.2.2 | TRENCHING & CONCRETE INSTALLATION | 153.862 | 0.087 | 1.570 | 1.657 |
| 1.4.2.2.1 | FOOTING CONCRETE & RE-BAR | 82.860 | 0.0 | 0.0 | 0.0 |
| 1.4.2.2.2 | MACHINERY & EQUIPMENT - GRS CONSTRU | 0.872 | 0.087 | 1.570 | 1.657 |
| 1.4.2.2.3 | CONSTRUCTION OPERATIONS | 70.150 | 0.0 | 0.0 | 0.0 |
| 1.4.2.3 | SUPPORT STRUCTURE DUTY | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.4.3 | POWER COLLECTION | 1583.244 | 0.0 | 0.0 | 0.0 |
| 1.4.3.1 | ANTENNA ARRAY ELEMENTS | 1318.966 | 0.0 | 0.0 | 0.0 |
| 1.4.3.2 | POWER DISTRIBUTION SYSTEM | 81.501 | 0.0 | 0.0 | 0.0 |
| 1.4.3.3 | INSTALLATION & CHECKOUT | 182.777 | 0.0 | 0.0 | 0.0 |
| 1.4.3.4 | POWER COLLECTION-DUTY | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.4.4 | CONTROL | 87.750 | 0.0 | 0.0 | 0.0 |
| 1.4.4.1 | CONTROL CENTER EQUIPMENT | 17.550 | 0.0 | 0.0 | 0.0 |
| 1.4.4.2 | CONTROL ELECTRONICS | 70.200 | 0.0 | 0.0 | 0.0 |
| 1.4.4.3 | CONTROL DUTY | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.4.5 | GRID INTERFACE | 106.181 | 0.0 | 0.0 | 0.0 |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
 TABLE SATELLITE POWER SYSTEM (SPS) PROGRAM PRE-IOC COSTS

| NBS # | DESCRIPTION | *****PRE-IOC ***** | | | TOTAL PRE-IOC |
|---------|----------------------------|--|---------|---------|------------------|
| | | AVERAGE OPS LOST PER SAT/YR INV PER SAT | RCI-PRE | OEN-PRE | |
| 1.4.5.1 | ELECTRICAL EQUIPMENT | 186.181 | 0.0 | 0.0 | 0.0 |
| 1.4.5.2 | GRID INTERFACE-UTCE | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.4.6 | OPERATIONS | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.4.6.1 | OPER. & MAINT. PERSONNEL | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.4.6.2 | MAINT. MATERIAL | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.5 | MANAGEMENT AND INTEGRATION | 569.734 | 3.395 | 0.264 | 3.659 |
| 1.6 | MASS CONTINGENCY | 778.208 | 0.650 | 0.557 | 1.207 |

B.4.3 SPS POST-IOC OPERATIONS

Post-IOC operations cost includes replacement capital of systems, facilities and equipment, plus those expenditures incurred in the day-to-day operational activities beginning with SPS-IOC and continuing over the life of each SPS. Examples of RCI costs in this category are spares, their installation and transportation charges, plus permanent improvements in major systems. O&M costs cover such things as wages of maintenance personnel, minor repairs and adjustments to maintain system operation, and the transportation cost of personnel along with expendable and consumables.

Table B-11 presents a summary of operations cost in this category. These estimates cover post-IOC periods and are identified as average annual expenditures for each SPS. Replacement capital is required primarily for the satellite system, operational support facilities and transportation vehicles. O&M expenditures are needed to support 1) mobile maintenance bases that service the satellite, 2) space transportation systems for transfer of mass to orbit, and 3) personnel/maintenance materials needed at the ground receiving station.

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE B-11. SATELLITE POWER SYSTEM (SPS) PROGRAM POST-IOC COSTS

| NBS # | DESCRIPTION | ***POST-IOC ****00000000 | | TOTAL POST-IOC |
|-----------|--------------------------------------|---------------------------------|----------|-------------------|
| | | OPS COST PER SAT/YR RCI-POST | O&M-POST | |
| 1 | SATELLITE POWER SYSTEM (SPS) PROGRAM | 73.828 | 71.146 | 144.974 |
| 1.1 | SATELLITE SYSTEM | 33.025 | 0.720 | 33.745 |
| 1.1.1 | ENERGY CONVERSION - SATELLITE | 7.512 | 0.026 | 7.538 |
| 1.1.1.1 | STRUCTURE | 0.161 | 0.015 | 0.176 |
| 1.1.1.1.1 | PRIMARY STRUCTURE | 0.0 | 0.0 | 0.0 |
| 1.1.1.1.2 | SECONDARY STRUCTURE | 0.152 | 0.0 | 0.152 |
| 1.1.1.1.3 | MECHANISMS | 0.009 | 0.015 | 0.024 |
| 1.1.1.2 | CONCENTRATORS | 0.092 | 0.0 | 0.092 |
| 1.1.1.3 | SOLAR BLANKETS | 4.258 | 0.0 | 4.258 |
| 1.1.1.4 | POWER DIST. & CONDITIONING | 2.715 | 0.011 | 2.726 |
| 1.1.1.4.1 | SWITCH GEAR & REGULATORS - E.C. | 2.503 | 0.0 | 2.503 |
| 1.1.1.4.2 | LO-VOLTAGE CONVERTERS - E.C. | 0.122 | 0.0 | 0.122 |
| 1.1.1.4.3 | CONDUCTORS & INSULATION | 0.0 | 0.0 | 0.0 |
| 1.1.1.4.4 | SLIP RINGS | 0.076 | 0.0 | 0.076 |
| 1.1.1.4.5 | BATTERIES | 0.007 | 0.011 | 0.018 |
| 1.1.1.4.6 | BATTERY PDC | 0.007 | 0.0 | 0.007 |
| 1.1.1.5 | THERMAL CONTROL | 0.0 | 0.0 | 0.0 |
| 1.1.1.6 | MAINTENANCE | 0.285 | 0.0 | 0.285 |
| 1.1.1.6.1 | MAINTENANCE - FREE FLYERS | 0.188 | 0.0 | 0.188 |
| 1.1.1.6.2 | MANNED MANIPULATOR | 0.098 | 0.0 | 0.098 |
| 1.1.1.6.3 | TRACKS & ACCESS WAYS | 0.0 | 0.0 | 0.0 |
| 1.1.2 | POWER TRANSMISSION - SATELLITE | 24.431 | 0.569 | 25.000 |
| 1.1.2.1 | STRUCTURE | 0.213 | 0.015 | 0.228 |
| 1.1.2.1.1 | PRIMARY STRUCTURE | 0.0 | 0.0 | 0.0 |
| 1.1.2.1.2 | SECONDARY STRUCTURE | 0.210 | 0.0 | 0.210 |
| 1.1.2.1.3 | MECHANISMS (TRUNNIONS) | 0.003 | 0.015 | 0.018 |
| 1.1.2.2 | TRANSMITTER SUBARRAYS - KLYSTRONS | 11.474 | 0.0 | 11.479 |
| 1.1.2.2.1 | KLYSTRON MPT & RS DETE | 0.0 | 0.0 | 0.0 |
| 1.1.2.2.2 | WAVE GUIDE | 0.0 | 0.0 | 0.0 |
| 1.1.2.2.3 | HEAT PIPES -THERMAL | 0.0 | 0.0 | 0.0 |
| 1.1.2.2.4 | KLYSTRON POWER MODULE ELEMENT | 1.793 | 0.0 | 1.793 |
| 1.1.2.2.5 | PHASE SHIFTERS | 4.822 | 0.0 | 4.822 |
| 1.1.2.2.6 | PHASE CONTROL ELECTRONICS | 4.196 | 0.0 | 4.196 |
| 1.1.2.2.7 | POWER DIVIDERS & COMBINERS | 0.668 | 0.0 | 0.668 |
| 1.1.2.2.8 | MW SYSTEM INTERACTION | 0.0 | 0.0 | 0.0 |

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ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE B-11. SATELLITE POWER SYSTEM (SPS) PROGRAM POST-IOC COSTS

| WBS # | DESCRIPTION | ***POST-IOC ***** | | TOTAL POST-IOC |
|-----------|--------------------------------------|----------------------|------------------------|-------------------|
| | | OPS COST RC1-POST | PER SAT/YR O&M-POST | |
| 1.1.2.3 | POWER DIST. & CONDITIONING | 12.039 | 0.543 | 12.581 |
| 1.1.2.3.1 | SWITCH GEAR & REGULATORS | 2.527 | 0.0 | 2.527 |
| 1.1.2.3.2 | HI-VOLTAGE CONVERTERS | 8.988 | 0.0 | 8.988 |
| 1.1.2.3.3 | LO-VOLTAGE CONVERTERS | 0.039 | 0.0 | 0.039 |
| 1.1.2.3.4 | CONDUCTORS & INSULATION | 0.0 | 0.0 | 0.0 |
| 1.1.2.3.5 | BATTERIES | 0.349 | 0.543 | 0.891 |
| 1.1.2.3.6 | BATTERY P&C | 0.137 | 0.0 | 0.137 |
| 1.1.2.4 | THERMAL CONTROL - INSULATION | 0.0 | 0.0 | 0.0 |
| 1.1.2.5 | CONTROL - PHASE REFERENCE | 0.307 | 0.012 | 0.319 |
| 1.1.2.5.1 | REFERENCE FREQUENCY GENERATOR | 0.004 | 0.012 | 0.016 |
| 1.1.2.5.2 | DIST. SYSTEM, COAXIAL CABLE | 0.0 | 0.0 | 0.0 |
| 1.1.2.5.3 | DIST. SYSTEM, DEVICES | 0.303 | 0.0 | 0.303 |
| 1.1.2.6 | MAINTENANCE | 0.394 | 0.0 | 0.394 |
| 1.1.2.6.1 | MAINTENANCE - FREE FLYERS | 0.222 | 0.0 | 0.222 |
| 1.1.2.6.2 | GANTRY CRANE | 0.0 | 0.0 | 0.0 |
| 1.1.2.6.3 | UN-CRANE CONTROL CENTER | 0.172 | 0.0 | 0.172 |
| 1.1.2.6.4 | TRACKS & ACCESS WAYS | 0.0 | 0.0 | 0.0 |
| 1.1.3 | INFORMATION MGMT. & CONTROL - SATELL | 0.631 | 0.0 | 0.631 |
| 1.1.3.1 | MASTER CONTROL COMPUTER | 0.010 | 0.0 | 0.010 |
| 1.1.3.2 | DISPLAYS & CONTROLS | 0.002 | 0.0 | 0.002 |
| 1.1.3.3 | SUPERVISORY COMPUTER | 0.004 | 0.0 | 0.004 |
| 1.1.3.4 | REMOTE COMPUTER | 0.009 | 0.0 | 0.009 |
| 1.1.3.5 | BUS CONTROL UNIT | 0.020 | 0.0 | 0.020 |
| 1.1.3.6 | MICROPROCESSORS | 0.019 | 0.0 | 0.019 |
| 1.1.3.7 | REMOTE ACQUISITION & CONTROL | 0.021 | 0.0 | 0.021 |
| 1.1.3.8 | SUBMULTIPLEXORS | 0.228 | 0.0 | 0.228 |
| 1.1.3.9 | INSTRUMENTATION | 0.264 | 0.0 | 0.264 |
| 1.1.3.10 | OPTICAL FIBER | 0.002 | 0.0 | 0.002 |
| 1.1.3.11 | CABLES/HARNESSES | 0.051 | 0.0 | 0.051 |
| 1.1.4 | ATTITUDE CONTROL & STATIONKEEPING -S | 0.233 | 0.100 | 0.333 |
| 1.1.4.1 | ACS HARDWARE | 0.233 | 0.0 | 0.233 |
| 1.1.4.1.1 | ACS THRUSTER COMPONENTS | 0.233 | 0.0 | 0.233 |
| 1.1.4.1.2 | ACS - CONDUCTORS & INSULATION | 0.0 | 0.0 | 0.0 |
| 1.1.4.1.3 | ACS - POWER PROCESSING EQUIPMENT | 0.0 | 0.0 | 0.0 |
| 1.1.4.1.4 | ACS - THRUSTER GIMBALS AND MOUNTING | 0.0 | 0.0 | 0.0 |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE B-11. SATELLITE POWER SYSTEM (SPS) PROGRAM POST-IOC COSTS

| WBS # | DESCRIPTION | ***POST-IOC ***** | | TOTAL POST-IOC |
|------------|-------------------------------------|---------------------------------|----------|-------------------|
| | | OPS COST PER SAT/YR RCI-POST | O&M-POST | |
| 1.1.4.2 | ACSS PROPELLANT | 0.0 | 0.100 | 0.100 |
| 1.1.5 | COMMUNICATIONS - SATELLITE | 0.0 | 0.0 | 0.0 |
| 1.1.5.1 | SATELLITE TO GROUND | 0.0 | 0.0 | 0.0 |
| 1.1.5.2 | SATELLITE TO RESUPPLY VEHICLES | 0.0 | 0.0 | 0.0 |
| 1.1.5.3 | SATELLITE INTERCOM | 0.0 | 0.0 | 0.0 |
| 1.1.6 | INTERFACE - SATELLITE | 0.218 | 0.025 | 0.243 |
| 1.1.6.1 | STRUCTURE | 0.010 | 0.0 | 0.010 |
| 1.1.6.1.1 | PRIMARY STRUCTURE | 0.0 | 0.0 | 0.0 |
| 1.1.6.1.2 | SECONDARY STRUCTURE | 0.010 | 0.0 | 0.010 |
| 1.1.6.2 | MECHANISMS - INTERFACE | 0.038 | 0.025 | 0.063 |
| 1.1.6.3 | POWER DISTRIBUTION | 0.012 | 0.0 | 0.012 |
| 1.1.6.3.1 | CONDUCTOR & INSULATION | 0.0 | 0.0 | 0.0 |
| 1.1.6.3.2 | SLIP RING BRUSHES | 0.012 | 0.0 | 0.012 |
| 1.1.6.4 | THERMAL CONTROL | 0.0 | 0.0 | 0.0 |
| 1.1.6.5 | MAINTENANCE | 0.158 | 0.0 | 0.158 |
| 1.1.6.5.1 | MAINTENANCE - FREE FLYERS | 0.041 | 0.0 | 0.041 |
| 1.1.6.5.2 | MANNED MANIPULATOR | 0.117 | 0.0 | 0.117 |
| 1.1.6.5.3 | TRACKS & ACCESSWAYS | 0.0 | 0.0 | 0.0 |
| 1.1.7 | SYSTEMS TEST - SATELLITE | 0.0 | 0.0 | 0.0 |
| 1.1.7.1 | SYSTEM GROUND TEST HARDWARE | 0.0 | 0.0 | 0.0 |
| 1.1.7.2 | SYSTEM GROUND TEST OPERATIONS | 0.0 | 0.0 | 0.0 |
| 1.1.8 | GROUND SUPPORT EQUIPMENT- SATELLITE | 0.0 | 0.0 | 0.0 |
| 1.1.9 | PROOF-OF-CONCEPT PILOT PLANT | 0.0 | 0.0 | 0.0 |
| 1.1.9.1 | CUHV PRECURSOR VEHICLE | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.1 | PRIMARY STRUCTURE - E.C. | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.2 | SECONDARY STRUCTURE - E.C. | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.3 | MECHANISMS - PRECURSOR E.C. | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.4 | CONCENTRATOR - E.C. | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.5 | SOLAR BLANKET - E.C. | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.6 | SWITCHGEAR & REGULATORS - E.C. | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.7 | LV-VOLTAGE CONVERTERS - E.C. | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.8 | CONDUCTORS & INSULATION - E.C. | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.9 | ACS HARDWARE - E.C. | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.10 | ACS - CONDUCTORS & INSUL - E.C. | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.11 | ACS - BATTERIES - E.C. | 0.0 | 0.0 | 0.0 |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE B-11. SATELLITE POWER SYSTEM (SPS) PROGRAM POST-IUC COSTS

| NBS # | DESCRIPTION | POST-IUC COST PER SAT/YR | | TOTAL POST-IUC |
|------------|--|--------------------------|----------|-------------------|
| | | RCI-POST | DEM-POST | |
| 1.1.9.1.12 | ALS - BATTERY PDEC - E.C. | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.13 | SLIPRINGS - PRECURSOR E.C. | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.14 | TRACKS & ACCESSWAYS - E.C. | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.15 | PRIMARY STRUCTURE - INTERFACE | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.16 | SECONDARY STRUCTURE - INTERFACE | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.17 | MECHANISMS - INTERFACE | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.18 | CONDUCTORS & INSULATION - INTERFACE | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.19 | SLIPRING BRUSHES - PRECURSOR - INTER | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.20 | PRIMARY STRUCTURE - POWER TRANS | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.21 | SECONDARY STRUCTURE - POWER TRANS | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.22 | MECHANISMS - POWER TRANS. | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.23 | P.T. KLYSTRON SUBARRAY OUTLET | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.24 | P.T. KLYSTRON WAVEGUIDE | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.25 | P.T. KLYSTRON HEATPIPER | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.26 | P.T. KLYSTRON P.M. ELEMENT | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.27 | P.T. KLYSTRON PHASE SHIFTERS | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.28 | P. T. KLYSTRON P.M. CONTROL ELECTRONIC | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.29 | P. T. KLYSTRON POWER DIVIDERS AND CO | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.30 | KLYSTRON SUBARRAY SYSTEM INTEGRATION | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.31 | PDEC - SW. GR. & REGULATORS - P.T. | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.32 | PDEC - HI VOLTAGE CONVERT - P.T. | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.33 | PDEC - LO VOLTAGE CONVERT - P.T. | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.34 | PDEC CONDUCTORS & INSULATION - P. T. | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.35 | BATTERIES - P.T. PRECURSOR | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.36 | P.T. - BATTERY PDEC | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.37 | THERMAL CONTROL - INSULATION - PRECU | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.38 | REFERENCE FREQUENCY GENERATOR - PREC | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.39 | DIST. SYSTEM, COAXIAL CABLE | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.40 | DIST. SYSTEM DEVICES | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.41 | P.T. - MASTER CONTROL COMPUTER - IMS | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.42 | P.T. BUS CONTROL UNIT | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.43 | P.T. - MICROPROCESSORS - IMS/COM | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.44 | P.T. - REMOTE AC & CONTROL - IMS/CO | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.45 | P.T. - SUBMULTIPLEXER - IMS/COM | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.46 | P.T. - INSTRUMENTATION - IMS/COM | 0.0 | 0.0 | 0.0 |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
 TABLE B-11. SATELLITE POWER SYSTEM (SPS) PROGRAM POST-IOC COSTS

| WBS # | DESCRIPTION | ***POST-IOC ***** | | TOTAL POST-IOC |
|------------|--------------------------------------|---------------------------------|----------|-------------------|
| | | UPS COST PER SAT/YR RCI-POST | DEM-POST | |
| 1.1.9.1.47 | P.T. - CABLES & HARNESS - IMS/COM | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.48 | P.T. TRACKS AND ACCESSWAYS FOR MH AN | 0.0 | 0.0 | 0.0 |
| 1.1.9.1.49 | P.T. ANT. MH LIFTS - INSTALL & C/O E | 0.0 | 0.0 | 0.0 |
| 1.1.9.2 | PRECURSOR OPERATIONS | 0.0 | 0.0 | 0.0 |
| 1.1.9.2.1 | PRECURSOR STS TRANSPORTATION | 0.0 | 0.0 | 0.0 |
| 1.1.9.2.2 | PRECURSOR CONSTRUCTION CREW | 0.0 | 0.0 | 0.0 |
| 1.1.9.2.3 | PRECURSOR GEO TEST ACTIVITY | 0.0 | 0.0 | 0.0 |
| 1.1.9.2.4 | PRECURSOR PROPELLANT | 0.0 | 0.0 | 0.0 |
| 1.1.9.3 | PRECURSOR GROUND RECEIVING FACILITY | 0.0 | 0.0 | 0.0 |
| 1.2 | SPACE CONSTRUCTION & SUPPORT | 15.134 | 15.628 | 30.762 |
| 1.2.1 | CONSTRUCTION FACILITIES | 0.0 | 0.0 | 0.0 |
| 1.2.1.1 | WORK SUPPORT FACILITIES | 0.0 | 0.0 | 0.0 |
| 1.2.1.1.1 | BEAM MACHINE | 0.0 | 0.0 | 0.0 |
| 1.2.1.1.2 | BEAM MACHINE CASSETTES SET | 0.0 | 0.0 | 0.0 |
| 1.2.1.1.3 | CABLE ATTACHMENT MACHINE | 0.0 | 0.0 | 0.0 |
| 1.2.1.1.4 | REMOTE MANIPULATOR | 0.0 | 0.0 | 0.0 |
| 1.2.1.1.5 | BLANKET DISPENSER MACHINE | 0.0 | 0.0 | 0.0 |
| 1.2.1.1.6 | SOLAR BLANKET CASSETTES | 0.0 | 0.0 | 0.0 |
| 1.2.1.1.7 | REFLECTOR DISPENSER MACHINE | 0.0 | 0.0 | 0.0 |
| 1.2.1.1.8 | REFLECTOR CASSETTES | 0.0 | 0.0 | 0.0 |
| 1.2.1.1.9 | CABLE/CATENARY DISPENSER MACHINES | 0.0 | 0.0 | 0.0 |
| 1.2.1.1.10 | ANTENNA PANEL INS. EMT. | 0.0 | 0.0 | 0.0 |
| 1.2.1.1.11 | GANTRY/CRANES | 0.0 | 0.0 | 0.0 |
| 1.2.1.1.12 | CARGO STORAGE DEPOS | 0.0 | 0.0 | 0.0 |
| 1.2.1.1.13 | FAB FIXTURE | 0.0 | 0.0 | 0.0 |
| 1.2.1.1.14 | AIRLOCK DUCKING MODULE (ADM) | 0.0 | 0.0 | 0.0 |
| 1.2.1.1.15 | BASE MGMT. MODULE (BMM) | 0.0 | 0.0 | 0.0 |
| 1.2.1.1.16 | POWER MODULE (PM) | 0.0 | 0.0 | 0.0 |
| 1.2.1.1.17 | PRESSURIZED STORAGE MODULE (PSM) | 0.0 | 0.0 | 0.0 |
| 1.2.1.2 | CREW SUPPORT FACILITIES-SCB | 0.0 | 0.0 | 0.0 |
| 1.2.1.2.1 | AIRLOCK DUCKING MODULE-ADM | 0.0 | 0.0 | 0.0 |
| 1.2.1.2.2 | CREW HABITABILITY MODULE-CHM | 0.0 | 0.0 | 0.0 |
| 1.2.1.2.3 | CONSUMABLES LOGISTICS MODULE-CLM | 0.0 | 0.0 | 0.0 |
| 1.2.1.2.4 | SHIELDING | 0.0 | 0.0 | 0.0 |
| 1.2.1.2.5 | CREW SUPPORT MODULE-CSM | 0.0 | 0.0 | 0.0 |

RUCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE B-11. SATELLITE POWER SYSTEM (SPS) PROGRAM POST-IOC COSTS

| WBS # | DESCRIPTION | ***POST-IOC ***** | | |
|-----------|--------------------------------------|----------------------|------------------------|-------------------|
| | | UPS COST RCI-POST | PER SAT/YR O&M-POST | TOTAL POST-IOC |
| 1.2.1.3 | OPERATIONS | 0.0 | 0.0 | 0.0 |
| 1.2.1.3.1 | OPERATIONS, CONSTRUCTION CREW | 0.0 | 0.0 | 0.0 |
| 1.2.1.3.2 | ORBITAL OPERATIONS, CONST. PROV. | 0.0 | 0.0 | 0.0 |
| 1.2.2 | LOGISTICS SUPPORT FACILITIES-LEO | 0.119 | 0.130 | 0.250 |
| 1.2.2.1 | WORK SUPPORT FACILITIES | 0.077 | 0.077 | 0.155 |
| 1.2.2.1.1 | BASE MGMT. MODULE-PM | 0.040 | 0.040 | 0.080 |
| 1.2.2.1.2 | POWER MODULE-PM | 0.035 | 0.035 | 0.071 |
| 1.2.2.1.3 | AIRLOCK DOCKING MODULE - ADM | 0.002 | 0.002 | 0.004 |
| 1.2.2.2 | CREW SUPPORT FACILITIES | 0.042 | 0.042 | 0.084 |
| 1.2.2.2.1 | CREW HABITABILITY MODULE-CMH | 0.013 | 0.013 | 0.026 |
| 1.2.2.2.2 | CONSUMABLES LOGISTICS MODULE CLM | 0.009 | 0.009 | 0.018 |
| 1.2.2.2.3 | CREW SUPPORT MODULE/EVA | 0.020 | 0.020 | 0.040 |
| 1.2.2.3 | OPERATIONS | 0.0 | 0.011 | 0.011 |
| 1.2.2.3.1 | LEO OPERATIONS CREW | 0.0 | 0.007 | 0.007 |
| 1.2.2.3.2 | LEO CREW PROVISIONS | 0.0 | 0.003 | 0.003 |
| 1.2.3 | O&M SUPPORT FACILITIES - SATELLITE | 15.015 | 15.497 | 30.512 |
| 1.2.3.1 | WORK SUPPORT FACILITIES | 14.170 | 14.170 | 28.340 |
| 1.2.3.1.1 | AIRLOCK DOCKING MODULE-ADM | 0.110 | 0.110 | 0.220 |
| 1.2.3.1.2 | BASE MGMT MODULE-BMM | 11.537 | 11.537 | 23.073 |
| 1.2.3.1.3 | PRESSURIZED STORAGE MODULE-PSM | 0.516 | 0.516 | 1.031 |
| 1.2.3.1.4 | POWER MODULE-PM | 2.007 | 2.008 | 4.015 |
| 1.2.3.2 | CREW SUPPORT FACILITIES | 0.845 | 0.845 | 1.690 |
| 1.2.3.2.1 | CREW HABITABILITY MODULE-CMH | 0.501 | 0.501 | 1.001 |
| 1.2.3.2.2 | CONSUMABLES LOGISTICS MODULE-CLM | 0.344 | 0.344 | 0.689 |
| 1.2.3.3 | OPERATIONS | 0.0 | 0.482 | 0.482 |
| 1.2.3.3.1 | SATELLITE OPERATIONS CREW - SCB | 0.0 | 0.039 | 0.039 |
| 1.2.3.3.2 | SATELLITE OPERATIONS CREW - MMH | 0.0 | 0.292 | 0.292 |
| 1.2.3.3.3 | CREW PROVISIONS - SCB | 0.0 | 0.018 | 0.018 |
| 1.2.3.3.4 | O&M CREW PROVISIONS - MMH | 0.0 | 0.133 | 0.133 |
| 1.3 | TRANSPORTATION | 15.039 | 17.419 | 32.459 |
| 1.3.1 | SPS-HEAVY LIFT LAUNCH VEHICLE(HLLV) | 13.377 | 13.150 | 26.527 |
| 1.3.1.1 | SPS-HLLV FLEET | 13.377 | 8.855 | 22.232 |
| 1.3.1.2 | SPS-HLLV OPERATIONS (VIO-HL) | 0.0 | 4.294 | 4.294 |
| 1.3.2 | CARGO ORBITAL TRANSFER VEHICLE(COTV) | 0.735 | 2.109 | 2.844 |
| 1.3.2.1 | COTV VEHICLES | 0.735 | 2.071 | 2.806 |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE B-11. SATELLITE POWER SYSTEM (SPS) PROGRAM POST-IOC COSTS

| WBS # | DESCRIPTION | ***POST-IOC ***** | | TOTAL POST-IOC |
|------------|--------------------------------------|---------------------------------|----------|-------------------|
| | | OPS COST PER SAT/YR RCI-POST | DEM-POST | |
| 1.3.2.1.1 | PRIMARY STRUCTURE | 0.0 | 0.005 | 0.005 |
| 1.3.2.1.2 | SECONDARY STRUCTURE | 0.011 | 0.114 | 0.126 |
| 1.3.2.1.3 | MECHANISMS - EDTV | 0.0 | 0.009 | 0.009 |
| 1.3.2.1.4 | TRACKS AND ACCESSWAYS | 0.0 | 0.000 | 0.000 |
| 1.3.2.1.5 | CONCENTRATOR | 0.001 | 0.007 | 0.007 |
| 1.3.2.1.6 | SOLAR BLANKET | 0.010 | 0.182 | 0.200 |
| 1.3.2.1.7 | SWITCHGEAR AND REGULATORS | 0.000 | 0.005 | 0.005 |
| 1.3.2.1.8 | LO-VOLTAGE CONVERTERS | 0.000 | 0.000 | 0.000 |
| 1.3.2.1.9 | CONDUCTORS AND INSULATION | 0.0 | 0.003 | 0.003 |
| 1.3.2.1.10 | BATTERIES | 0.632 | 1.043 | 1.675 |
| 1.3.2.1.11 | BATTERY POCB | 0.004 | 0.027 | 0.031 |
| 1.3.2.1.12 | ACS HARDWARE-CUTV | 0.063 | 0.626 | 0.689 |
| 1.3.2.1.13 | INFU. MONI. AND CONTROL | 0.005 | 0.050 | 0.055 |
| 1.3.2.2 | COTV OPERATIONS | 0.0 | 0.030 | 0.030 |
| 1.3.3 | STS PERSONNEL CARGO LAUNCH VEHICLE | 0.0 | 0.0 | 0.0 |
| 1.3.3.1 | STS CARGO CARRIER AND EM | 0.0 | 0.0 | 0.0 |
| 1.3.3.2 | STS OPERATIONS - GROWTH AND DERIVATI | 0.0 | 0.0 | 0.0 |
| 1.3.3.2.1 | OPERATIONS-STS GROWTH HLLV | 0.0 | 0.0 | 0.0 |
| 1.3.3.2.2 | OPERATIONS - STS DERIVATIVE | 0.0 | 0.0 | 0.0 |
| 1.3.4 | PERSONNEL ORBITAL TRANS VEHICLE | 0.047 | 0.031 | 0.078 |
| 1.3.4.1 | POTV-FLEET | 0.047 | 0.024 | 0.071 |
| 1.3.4.2 | POTV-OPERATIONS | 0.0 | 0.007 | 0.007 |
| 1.3.5 | PERSONNEL MODULI (PM) | 0.083 | 0.034 | 0.117 |
| 1.3.5.1 | PM FLEET | 0.083 | 0.028 | 0.110 |
| 1.3.5.2 | PM OPERATIONS | 0.0 | 0.006 | 0.006 |
| 1.3.6 | INTRAORBITAL TRANSFER VEHICLE (IOTV) | 0.036 | 0.019 | 0.055 |
| 1.3.6.1 | IOTV FLEET | 0.036 | 0.018 | 0.055 |
| 1.3.6.2 | IOTV OPERATIONS | 0.0 | 0.001 | 0.001 |
| 1.3.7 | GROUND SUPPORT FACILITIES | 0.761 | 2.077 | 2.838 |
| 1.3.7.1 | LAUNCH FACILITIES | 0.0 | 0.0 | 0.0 |
| 1.3.7.2 | RECOVERY FACILITIES | 0.0 | 0.0 | 0.0 |
| 1.3.7.3 | FUEL FACILITIES | 0.0 | 0.0 | 0.0 |
| 1.3.7.4 | LOGISTICS SUPPORT | 0.0 | 0.0 | 0.0 |
| 1.3.7.5 | OPERATIONS | 0.0 | 0.0 | 0.0 |
| 1.4 | GROUND RECEIVING STATION | 0.254 | 31.656 | 31.890 |

ROCKWELL SPS LR-2 REFERENCE CONFIGURATION, 1980
TABLE B-11. SATELLITE POWER SYSTEM (SPS) PROGRAM POST-IOC COSTS

| WBS # | DESCRIPTION | ***POST-IOC ***** | | TOTAL POST-IOC |
|-----------|--|---------------------------------|----------|-------------------|
| | | OPS COST PER SAT/YR RCI-POST | OEM-POST | |
| 1.4.1 | SITE AND FACILITIES | 0.234 | 0.094 | 0.328 |
| 1.4.1.1 | LAND AND PREPARATION | 0.0 | 0.0 | 0.0 |
| 1.4.1.1.1 | LAND | 0.0 | 0.0 | 0.0 |
| 1.4.1.1.2 | LAND PREPARATION | 0.0 | 0.0 | 0.0 |
| 1.4.1.2 | ROADS AND FENCES | 0.0 | 0.0 | 0.0 |
| 1.4.1.2.1 | RAILS AND ROADS | 0.0 | 0.0 | 0.0 |
| 1.4.1.2.2 | FENCING | 0.0 | 0.0 | 0.0 |
| 1.4.1.3 | UTILITIES | 0.0 | 0.0 | 0.0 |
| 1.4.1.4 | BUILDINGS | 0.0 | 0.0 | 0.0 |
| 1.4.1.4.1 | STORAGE, MAINTENANCE FACILITIES | 0.0 | 0.0 | 0.0 |
| 1.4.1.4.2 | COMM. STA. & MONITOR/CONTROL FAC. | 0.0 | 0.0 | 0.0 |
| 1.4.1.5 | MAINTENANCE EQUIP. FOR SITE & FACILITIES | 0.234 | 0.094 | 0.328 |
| 1.4.1.6 | LIGHTNING PROTECTION | 0.0 | 0.0 | 0.0 |
| 1.4.1.7 | SITE & FACILITIES UTILITY | 0.0 | 0.0 | 0.0 |
| 1.4.2 | RELIABLE SUPPORT STRUCTURE | 0.0 | 0.0 | 0.0 |
| 1.4.2.1 | STEEL PANEL FAB. & INSTALLATION | 0.0 | 0.0 | 0.0 |
| 1.4.2.1.1 | HAT SECTIONS | 0.0 | 0.0 | 0.0 |
| 1.4.2.1.2 | WIDE FLANGES | 0.0 | 0.0 | 0.0 |
| 1.4.2.1.3 | TUBE BRACES & HARDWARE | 0.0 | 0.0 | 0.0 |
| 1.4.2.1.4 | ASSEMBLY & INSTALLATION | 0.0 | 0.0 | 0.0 |
| 1.4.2.2 | TRENCHING & CONCRETE INSTALLATION | 0.0 | 0.0 | 0.0 |
| 1.4.2.2.1 | POURING CONCRETE & RE-BAR | 0.0 | 0.0 | 0.0 |
| 1.4.2.2.2 | MACHINERY & EQUIPMENT - GRS CONSTRU | 0.0 | 0.0 | 0.0 |
| 1.4.2.2.3 | CONSTRUCTION OPERATIONS | 0.0 | 0.0 | 0.0 |
| 1.4.2.3 | SUPPORT STRUCTURE UTILITY | 0.0 | 0.0 | 0.0 |
| 1.4.3 | POWER COLLECTION | 0.0 | 0.0 | 0.0 |
| 1.4.3.1 | ANTENNA ARRAY ELEMENTS | 0.0 | 0.0 | 0.0 |
| 1.4.3.2 | POWER DISTRIBUTION SYSTEM | 0.0 | 0.0 | 0.0 |
| 1.4.3.3 | INSTALLATION & CHECKOUT | 0.0 | 0.0 | 0.0 |
| 1.4.3.4 | POWER COLLECTION-UTILITY | 0.0 | 0.0 | 0.0 |
| 1.4.4 | CONTROL | 0.0 | 0.0 | 0.0 |
| 1.4.4.1 | CONTROL CENTER EQUIPMENT | 0.0 | 0.0 | 0.0 |
| 1.4.4.2 | CONTROL ELECTRONICS | 0.0 | 0.0 | 0.0 |
| 1.4.4.3 | CONTROL UTILITY | 0.0 | 0.0 | 0.0 |
| 1.4.5 | GRID INTERFACE | 0.0 | 0.0 | 0.0 |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE B-11. SATELLITE POWER SYSTEM (SPS) PROGRAM POST-IOC COSTS

| WBS # | DESCRIPTION | ***POST-IOC ***** | | TOTAL POST-IOC |
|---------|----------------------------|----------------------|------------------------|-------------------|
| | | OPS COST RCI-POST | PER SAT/YR O&M-POST | |
| 1.4.5.1 | ELECTRICAL EQUIPMENT | 0.0 | 0.0 | 0.0 |
| 1.4.5.2 | GRID INTERFACE-UNIT | 0.0 | 0.0 | 0.0 |
| 1.4.6 | OPERATIONS | 0.0 | 31.562 | 31.562 |
| 1.4.6.1 | OPER. & MAINT. PERSONNEL | 0.0 | 16.200 | 16.200 |
| 1.4.6.2 | MAINT. MATERIAL | 0.0 | 15.362 | 15.362 |
| 1.5 | MANAGEMENT AND INTEGRATION | 3.172 | 3.271 | 6.443 |
| 1.6 | MASS CONTINGENCY | 7.224 | 2.452 | 9.676 |

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1.0 SATELLITE POWER SYSTEM (SPS) PROGRAM COST ESTIMATES

This section of the appendix volume contains information on the identification of cost estimates for each of the approximately 300 line items within the SPS work breakdown structure. It includes cost for DDT&E, TFU, investment, and operational phase of the program covering satellite, space construction, transportation, and ground receiving station elements. Information within this volume emphasizes Rockwell's SPS reference concept—a 3-trough/planar/klystron configuration and in some instances, cost detail is provided on WBS line items of the other 4 SPS concepts to emphasize system variations within these configurations.

The Satellite Power Systems (SPS) concept is based upon a large photovoltaic power collection satellite located in a Geosynchronous, Equatorial Orbit (GEO) utilizing a microwave power transmission concept to transmit the collected energy to Ground Receiving Stations (GRS) located at selected sites within or near the continental United States. The ground receiving sites then convert the received energy to a form compatible with local utility power networks where the available energy will contribute to the base load power capability of the network.

All cost material on these concepts is organized by WBS element with supporting information, cost equations, technical characteristics, and results identified at the lowest possible level available from current system definitions and design concepts. Main areas of Appendix B cover:

1.0 Satellite Power System

- 1.1 Satellite System (page B-46)**
- 1.2 Space Construction and Support (page B-221)**
- 1.3 Transportation (page B-275)**
- 1.4 Ground Receiving Station (page B-325)**
- 1.5 Management and Integration (page B-374)**
- 1.6 Mass Contingency (page B-376)**

1.1 SATELLITE SYSTEM

Elements of the satellite system are costed in this section covering hardware, software, and services applicable to the Rockwell SPS reference concept—a 3-trough/planar/klystron configuration. Basic features of Rockwell satellites are the use of gallium arsenide based solar cells subjected to various concentrations of the sun's rays to convert solar energy into its electrical equivalent. Klystron, magnetron or solid state power amplifiers are used as the means of developing high power microwave energy for transmission to earth. Characteristics of the five concepts that were costed by WBS line item are presented in Table 1.1-1.

Table 1.1-1. Satellite System Concept Summaries
(June 1980)

| SATELLITE | GaAs SOLAR CELL | | | | GaAlAs/GaAs SOLAR CELL |
|--|---|---|--|---|---|
| | REFERENCE | DUAL END-MOUNTED | DUAL SANDWICH | MAGNETRON | DUAL SANDWICH |
| <u>SATELLITE</u> TYPE CR_f DIMENSION (METERS) MASS ($\times 10^6$ KG) SOLAR ARRAY/ANTENNA NUMBER OF BAYS | PLANAR 1.83 4200 \times 16,000 31.63 DECOUPLED 30 | PLANAR 1.83 4200 \times 18,000 39.97 DECOUPLED 36 | COMPOUND 5.2 6600 \times 28,500 20.53 SANDWICH - | PLANAR 1.83 4200 \times 15,000 26.80 DECOUPLED 30 | COMPOUND 5.2 TBD 16.39 SANDWICH - |
| <u>SOLAR ARRAY</u> NUMBER OF PANELS PANEL DIMENSION (METERS) AREA ($\times 10^6$ M ²) GEN. POWER (GW) | 60 650W \times 730L 28.47 9.94 | 72 650W \times 690L 32.29 11.46 | - 1.83D ($\times 2$) 5.26 4.82 | 60 650W \times 700L 27.3 9.8 | - 1.63D ($\times 2$) 4.17 6.11 |
| <u>ANTENNA</u> TYPE POWER OUTPUT (GW) ILLUMINATION APERTURE (KM) | KLYSTRON 7.14 10 dB GAUS. ~1.0 | SOLID STATE 7.36 10 dB GAUS. 1.35 | SOLID STATE 3.66 UNIFORM 1.83 ($\times 2$) | MAGNETRON 8.00 10 dB HANSEN 0.92 | SOLID STATE 4.64 UNIFORM 1.63 ($\times 2$) |
| UTILITY INTERFACE POWER (GW) | 5.07 | 5.22 | 2.42 | 5.6 | 3.06 |
| NO. OF SATELLITES ($P_T > 300$ GW) | 60 | 58 | 125 | 54 | 98 |
| MASS DENSITY (KG/KW _{UI}) ^a | 6.24 | 7.66 | 8.52 | 4.79 | 5.35 |
| ^a KW _{UI} = KILOWATTS AT UTILITY INTERFACE NETWORK | | | | | |

The updated Rockwell SPS reference configuration utilizes a klystron microwave power amplifier with an end-mounted antenna to form a microwave power transmission system receiving power from a GaAs based 3-trough planar solar array (Figure 1.1-1). Solar array panels are 730 m long and 650 m wide and two of these panels make up a voltage string (43.3 kV) when using a single junction

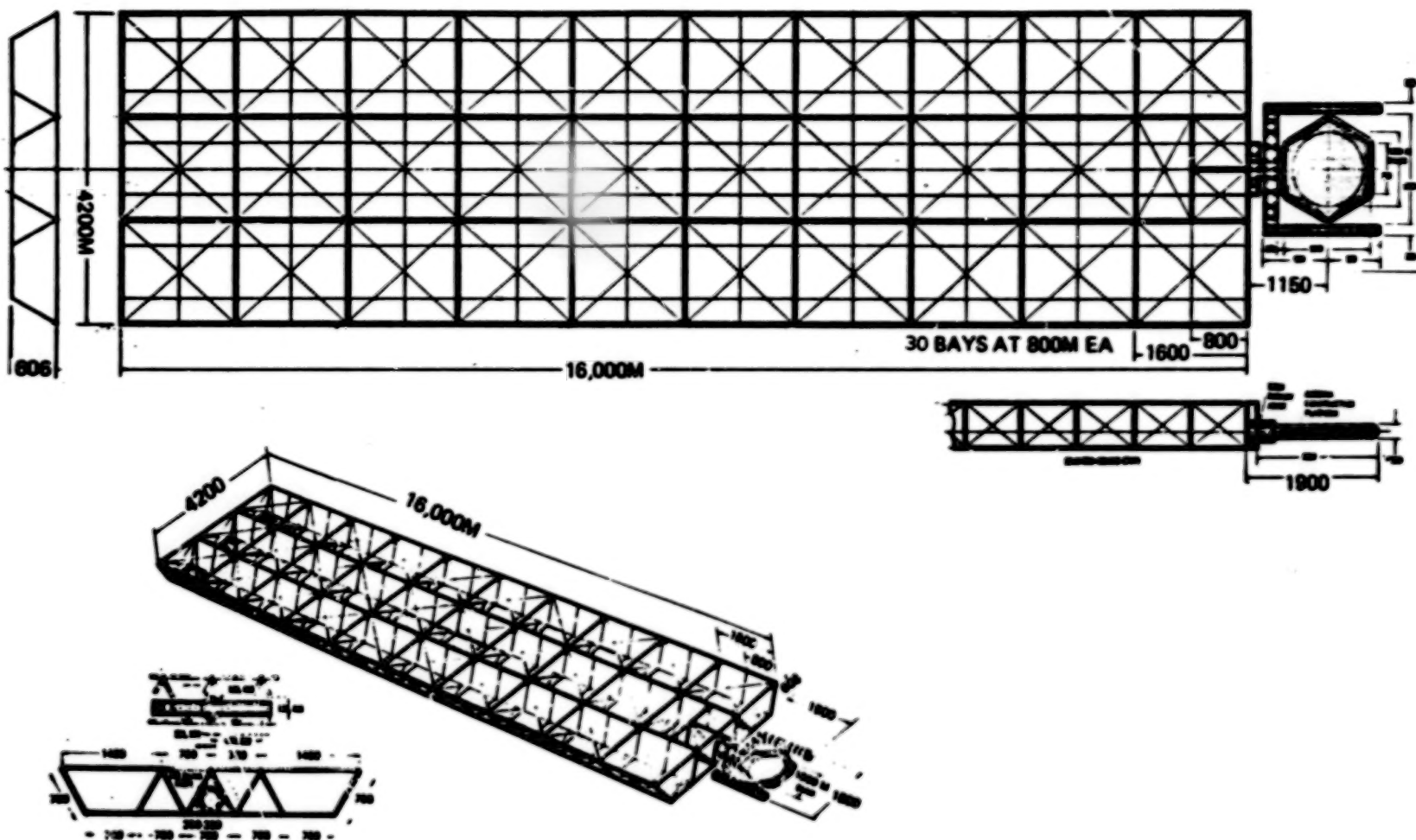


Figure 1.1-1. Rockwell SPS CR-2 Reference Configuration
(3 Trough/Planar/Klystron)—1980

GaAs cell. The 650 m width consists of 26 strips, each 25 m wide. Sizing of the array is based on a solar constant at summer solstice (1311.5 W/m^2), an end of life concentration ratio of 1.83, and an operating temperature of 113°C . The installed solar panel area is defined as $28.47 \times 10^6 \text{ m}^2$ for the standard GaAs cell. Total power from the solar array output is estimated to be 9.94 GW. Total spacetenna transmitted power is 7.14 GW.

Mass properties for the 5 concepts, as well as 3 others using MBG solar cells, were identified for the systems and elements that make-up the energy conversion, power transmission, and interface segment of the satellite. These masses were then used in all cost calculations based on values (dry) without a 25% growth factor. A summary mass properties statement used in cost calculations is shown in Table 1.1-2. This mass statement is consistent with SPS concepts presented in Figure B-2.

Cost estimates for the satellite were developed in accordance with the SPS-WBS breakdown presented in Appendix A. Approximately 100 line items were analyzed within the following areas of 1.1 Satellite System definition:

- 1.1.1 Energy Conversion (page B-50)
- 1.1.2 Power Transmission (page B-78)
- 1.1.3 Information Management and Control (p. B-120)
- 1.1.4 Attitude Control and Stationkeeping (p. B-134)
- 1.1.5 Communications (page B-142)
- 1.1.6 Interface (page B-143)
- 1.1.7 Systems Test (page B-158)
- 1.1.8 Ground Support Equipment (page B-161)

SPS research and technology studies have identified the need for a demonstration article or satellite to serve as an ultimate pilot plant with possible extension into a first SPS satellite system. Cost estimates for this pilot plant and test articles have been developed and are included as Section 1.1.9—Pilot Plant/Test Article (page B-163).

Table 1.1-2. Mass Properties Summary Statement
(September 1980)

| | | ROCKWELL SPS CONCEPTS | | | | | | | |
|---|------------------------------------|---|-----------------------------|---|-----------------------------|--|-----------------------------|--|-----------------------------|
| | | CR = 2 | | | | | | CR = 5 | |
| | | UPDATED REFERENCE 3-TROUGH PLASMA/ALYSTRON (kg x 10 ⁶) | | 3-TROUGH/PLASMA MAGNETRON (kg x 10 ⁶) | | PLASMA DUAL END MOUNTED SOLID STATE (kg x 10 ⁶) | | SOLID-STATE SANDWICH DUAL ANTENNA/REFLECTOR (kg x 10 ⁶) | |
| | | STANDARD CELL Gals | HMC CELL GaInAs/ Gals | STANDARD CELL Gals | HMC CELL GaInAs/ Gals | STANDARD CELL Gals | HMC CELL GaInAs/ Gals | STANDARD CELL Gals | HMC CELL GaInAs/ Gals |
| 1.1.1 | ENERGY CONVERSION (SOLAR ARRAY) | | | | | | | | |
| | STRUCTURE | 1.516 | 1.133 | 1.601 | 1.245 | 1.496 | 1.233 | 3.412 | 2.411 |
| | PRIMARY | (0.520) | (0.504) | (0.504) | (0.545) | (0.577) | (0.502) | (3.026) | (2.138) |
| | SECONDARY | (0.586) | (0.329) | (0.697) | (0.680) | (0.419) | (0.331) | (0.386) | (0.273) |
| | RECORDING | 0.070 | 0.070 | 0.070 | 0.070 | 0.087 | 0.078 | 0.027 | 0.019 |
| | CONCENTRATION | 1.030 | 0.648 | 0.908 | 0.663 | 1.169 | 0.764 | 2.075 | 1.646 |
| | SOLAR PANEL | 7.174 | 4.804 | 6.880 | 4.619 | 8.138 | 5.607 | 0.076* | 0.076* |
| | POWER DISTRIBUTION AND CONTROL | 2.757 | 1.388 | 4.146 | 2.874 | 1.112 | 0.846 | 0.015 | 0.015 |
| | POWER COND. EQUIPMENT & BATT. | (0.319) | (0.386) | (0.315) | (0.319) | (0.102) | (0.222) | (0.013) | (0.013) |
| | POWER DISTRIBUTION | (2.438) | (1.182) | (3.832) | (2.555) | (1.010) | (0.624) | (0.002) | (0.002) |
| | THERMAL | NONE | NONE | NONE | NONE | NONE | NONE | NONE | NONE |
| | MAINTENANCE | 0.052 | 0.063 | 0.052 | 0.052 | 0.104 | 0.054 | 0.180 | 0.100 |
| 1.1.3 | INFORMATION MANAGEMENT AND CONTROL | 0.050 | 0.050 | 0.050 | 0.050 | 0.057 | 0.057 | 0.033** | 0.033** |
| (PARTIAL) | DATA PROCESSING | (0.021) | (0.021) | (0.021) | (0.021) | (0.024) | (0.024) | (0.014) | (0.014) |
| | INSTRUMENTATION | (0.029) | (0.029) | (0.029) | (0.029) | (0.033) | (0.033) | (0.019) | (0.019) |
| 1.1.4 | ATTITUDE CONTROL | 0.116 | 0.116 | 0.116 | 0.116 | 0.116 | 0.116 | 0.103 | 0.103 |
| (PARTIAL) | | | | | | | | | |
| SUBTOTAL | | 12.803 | 8.272 | 13.943 | 9.729 | 12.279 | 8.759 | 5.841 | 4.403 |
| 1.1.2 | POWER TRANSMISSION (ANTENNA) | | | | | | | | |
| | STRUCTURE | 0.838 | 0.838 | 0.547 | 0.547 | 1.409 | 1.409 | 0.729 | 0.649 |
| | PRIMARY | (0.023) | (0.023) | (0.023) | (0.023) | (0.094) | (0.094) | (0.161) | (0.143) |
| | SECONDARY | (0.815) | (0.815) | (0.524) | (0.524) | (1.315) | (1.315) | (0.568) | (0.506) |
| | RECORDING | 0.001 | 0.002 | 0.002 | 0.002 | 0.004 | 0.004 | NONE | NONE |
| | SUBARRAY | 7.050 | 7.050 | 3.320 | 3.320 | 10.561 | 10.561 | 8.821 | 7.053 |
| | POWER DISTRIBUTION AND CONTROL | 2.453 | 2.453 | 1.515 | 1.515 | 4.405 | 4.405 | INCLUDED | INCLUDED |
| | POWER COND. & BATT. | (1.680) | (1.680) | (0.346) | (0.346) | (2.164) | (2.164) | -- | -- |
| | POWER DISTRIBUTION | (0.773) | (0.773) | (1.169) | (1.169) | (2.241) | (2.241) | -- | -- |
| | THERMAL | 0.720 | 0.720 | NONE | NONE | NONE | NONE | NONE | NONE |
| | ANTENNA CONTROL ELECTRONICS | 0.170 | 0.170 | 0.170 | 0.170 | 0.340 | 0.340 | 0.340 | 0.340 |
| | MAINTENANCE | 0.107 | 0.107 | 0.107 | 0.107 | 0.448 | 0.448 | 0.436 | 0.408 |
| 1.1.3 | INFORMATION MANAGEMENT AND CONTROL | 0.640 | 0.640 | 0.320 | 0.320 | 1.622 | 1.622 | 0.256** | 0.256** |
| (PARTIAL) | DATA PROCESSING | (0.380) | (0.380) | (0.190) | (0.190) | (1.385) | (1.385) | (0.152) | (0.152) |
| | INSTRUMENTATION | (0.260) | (0.260) | (0.130) | (0.130) | (0.237) | (0.237) | (0.104) | (0.104) |
| 1.1.4 | ATTITUDE CONTROL | NEG16. | NEG16. | NEG16. | NEG16. | NEG16. | NEG16. | NEG16. | NEG16. |
| (PARTIAL) | | | | | | | | | |
| SUBTOTAL | | 11.980 | 11.980 | 5.981 | 5.981 | 18.789 | 18.789 | 10.582 | 8.706 |
| 1.1.6 | INTERFACE | | | | | | | | |
| | STRUCTURE | 0.170 | 0.170 | 0.257 | 0.257 | 0.236 | 0.236 | N/A | N/A |
| | PRIMARY | (0.136) | (0.136) | (0.130) | (0.136) | (0.168) | (0.168) | | |
| | SECONDARY | (0.034) | (0.034) | (0.127) | (0.121) | (0.068) | (0.068) | | |
| | RECORDING | 0.033 | 0.033 | 0.033 | 0.033 | 0.072 | 0.072 | | |
| | POWER DISTRIBUTION AND CONTROL | 0.280 | 0.280 | 1.194 | 1.194 | 0.538 | 0.538 | | |
| | POWER DISTRIBUTION | (0.271) | (0.271) | (1.177) | (1.177) | (0.487) | (0.487) | | |
| | SLIP RING DRIVES | (0.017) | (0.017) | (0.017) | (0.017) | (0.051) | (0.051) | | |
| | THERMAL | NONE | NONE | NONE | NONE | NONE | NONE | N/A | N/A |
| | MAINTENANCE | 0.032 | 0.032 | 0.032 | 0.032 | 0.064 | 0.064 | -- | -- |
| | COMMUNICATION | 700 | 700 | 700 | 700 | 700 | 700 | 700 | 700 |
| SUBTOTAL | | 0.523 | 0.523 | 1.516 | 1.516 | 0.910 | 0.910 | -- | -- |
| SPS TOTAL (DRY) | | 22.705 | 20.775 | 21.44 | 17.226 | 31.978 | 28.458 | 16.423 | 13.109 |
| GROWTH (250) | | 6.326 | 5.194 | 5.36 | 4.307 | 7.995 | 7.114 | 4.188 | 3.277 |
| TOTAL SPS (DRY) WITH FADITH | | 31.632 | 25.969 | 26.8 | 21.533 | 39.973 | 35.572 | 20.611 | 16.386 |
| SATELLITE POWER AT UTILITY INTERFACE (kW) | | 5.07 | 5.07 | 5.6 | 5.6 | 5.22 | 5.22 | 2.41 | 3.08 |
| SATELLITE DENSITY, W/M ² | | 6.24 | 5.12 | 4.79 | 3.85 | 7.64 | 6.81 | 0.52 | 5.35 |
| *ANTENNA POWER ONLY | | | | | | | | | |
| **TWO-THIRD RADS OF REFERENCE CONCEPT | | | | | | | | | |
| ***ONE REFERENCE RADS PER ANTENNA | | | | | | | | | |

1.1.1 ENERGY CONVERSION

This element covers components required to collect solar energy, convert the solar energy to electrical energy, condition the electrical energy, and transport it to the interface subsystem (WBS No. 1.1.6).

The satellite "wing" structure, solar cells/blankets, concentrators, and power distribution/conditioning systems are included in this element plus maintenance equipment necessary to support the satellite during operational phases. The following WBS items are included in this section:

- Structure
- Concentrators
- Solar Blankets
- Power Distribution and Conditioning
- Thermal Control
- Maintenance

1.1.1.1 STRUCTURE

This element includes structural members that support concentrators, solar blankets, and other energy conversion subsystem hardware. It covers structural beams, beam couplers, cables, tensioning devices, and secondary structures required as an interface between the primary structure and the mounting attach points of components, assemblies, and subsystems.

1.1.1.1.1 Primary Structure

The satellite structure for various configurations may be considered in two broadly differing categories. The first category, applies to configurations utilizing a planar form, consists of the structure required to support the solar photovoltaic array, the rotary joint support structure, and basic antenna yoke elements. A special variant of the first category is used to establish requirements associated with the reflector/concentrator support structure. The second category is the antenna itself (WBS 1.1.2). Primary structural assemblies are made up of the tri-beam girders, tension cables, and joints. Fabrication and assembly of these structures is accomplished on orbit by beam machines and supporting auxiliary equipment (reference WBS 1.2). General configuration and design characteristics of basic tri-beam girders are illustrated in Figure 1.1-2.

Primary structural elements are made of a graphite fiber reinforced composite that must individually withstand the forces, torques, and dynamics imposed by the construction process. Once built into an assembly level, the structure must have sufficient strength and stiffness to withstand the forces of environment (gravity-gradient torques), attitude control system (forces and frequencies), and operational equipment (rotary joint microwave induced thermal environment).

The SPS requirement for low thermal distortion, under high thermal stress, dictates the need for a material with a very low coefficient of expansion. The most likely candidate, at this time, is a graphite composite material.

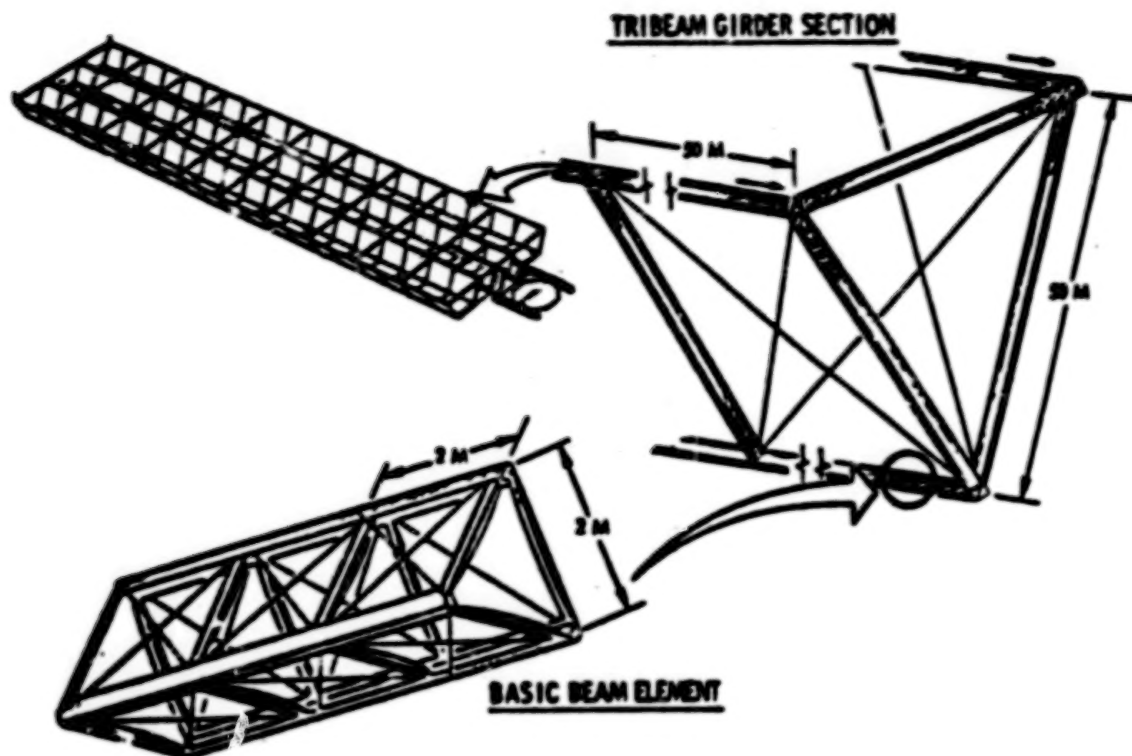


Figure 1.1-2. Primary Structure

A primary structure D&D CER was developed using graphite composite data obtained from NASA's Redstar Data Base. Tooling cost was excluded under the assumption that this cost would be incurred in the development of orbital fabrication equipment such as the beam machine. The following data points were used:

- Space Telescope Shell
- ATS-F Truss
- HEAO Optical Bench
- Shuttle Payload Bay Doors

The primary structure ICI includes the cost of raw materials only since costs associated with fabrication and assembly are costed under Space Construction and Support Equipment (WBS 1.2). The primary structure ICI cost equation is based on raw composite material stock (prepregnated graphite), where costs were obtained from vendor quotes obtained from Hercules, Fiberrite and Union Carbide.

Range of Data

D&D: 30.0 to 2000.0 kg
ICI: Unlimited

1.1.1.1.2 Secondary Structure

Secondary structure consists of passive interface attachments between primary structure and operational systems. Structural members are made of aluminum with the ability to articulate, rotate, or otherwise support/allow motion between the primary structure and other system elements.

This element includes all structure, consisting of mounting brackets, clamps and installation structure required as an interface and mounting attach points of components, assemblies, and subsystems. It also includes any structure required between two or more components or assemblies.

The MSFC CER was used for DDT&E and ICI costs as developed from cost data contained in the Redstar Data Base. Data from a variety of launch vehicle and unmanned satellite programs were available and the applicable data points are listed below:

| | |
|--|---------------------------------------|
| S-IV Interstage | UV Instrument Mounting Assembly (ASM) |
| S-IC Forward Skirt | Solar Array & Boom Structure (ATS-F) |
| S-IC Intertank | Squib Interface Unit (ATS-F) |
| Solar Telescope Housing Assembly (ASM) | Interstage (Centaur) |
| Common Mount Assembly (ASM) | Nose Shroud (Centaur) |
| Telescope Gimbal Assembly (ASM) | Fixed Airlack Shroud (Skylab) |
| Common Mount Actuators (ASM) | Payload Shroud (Skylab) |
| Telescope Gimbal Actuators (ASM) | Pallet Segment (Spacelab) |
| Array Platform Elevation Pointing Actuator (ASM) | OSO-1 |
| UV Gimbal Mount Actuators (ASM) | ATS-F |
| | S-II |

Range of Data

D&D: 6.0 to 15,000.0 kg
ICI: 6.0 to 15,000.0 kg

A review of these data points indicates extrapolations at the 6 kg level were based on the ATS-F Solar Array and Boom Structure, the Squib Interface Unit, ASM Gimbal Assemblies and Actuators; where as the S-IC Intertank, Centaur Nose Shroud, and interstages were extrapolated for the 1000 kg category. The design and size of these items is considered more complex than that required for the CPS, and as a result, a complexity factor (CR) of .80 was established for the pilot plant/test article and the COTV. A CF of .70 was used for the satellite as the two prior vehicles will be completed and an improved data base will be available for the satellite secondary structure.

Tooling factors were identified by grouping secondary structure requirements for the annual production of satellites (WBS 1.1.1.1.2—Energy Conversion, WBS 1.1.2.1.2—Power Transmission, and WBS 1.1.6.1.2—Interface).

1.1.1.1.3 Mechanisms

This element covers active components such as the drives and drive motors located at the interface/energy conversion/rotary joint for yoke rotation.

Structural mechanisms consist of active subassemblies that articulate, rotate or otherwise cause or allow motion between conversion and interface elements of the satellite.

The ICI production cost CER was based on data provided by the following manufacturers:

| <u>Manufacturer</u> | <u>Application</u> |
|---------------------|---------------------------------|
| Poly-Scientific | High energy |
| Poly-Scientific | Radar |
| Electro-Tec | Navy destroyer propeller system |
| Electro-Tec | Satellite solar array |
| I.E.C. | Navy shipboard hoist |

Due to the difference in complexity and variations in specification requirements between ground and space qualified equipment, the following factors were applied.

| | |
|--------------------------------|-----------------------------|
| Complexity Factor | $\times 3$ |
| Specification Upgrading factor | $\frac{\times 3}{\times 9}$ |
| Total | $\times 9$ |

Range of Data

| | |
|--------|--------------------|
| DDT&E: | 6.0 to 15,000.0 kg |
| ICI: | 6.0 to 15,000.0 kg |

1.1.1.1.4 Cost Estimates

Table 1.1.1.1.1, 1.1.1.1.2, and 1.1.1.1.3 cover cost estimates associated with the primary and secondary structure and mechanisms of the energy conversion segment.

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ROCKWELL SP'S CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.1.1.1 PRIMARY STRUCTURE

INPUT PARAMETERS

INPUT COEFFICIENTS

| | | | | | |
|------|------------|------|-----------|--------|----------|
| T= | 928000.000 | TF= | 1.000000 | CDCER= | 0.026910 |
| M= | 15467.0000 | DEM= | 0.0 | CDEXP= | 0.800000 |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.000050 |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 1.000000 |
| R= | 0.0 | Z3= | 60.000000 | BYEAR= | 1979 |
| DF= | 0.015000 | Z4= | 60.000000 | Z5= | 0.0 |
| | | | | Z6= | 0.0 |

CALCULATED VALUES

KG

SUM TO 1.1.1.1

\$, MILLIONS

CU=CDCER X (T X DF)XX(CDEXP) X CF 55.568

CLRM=CICER X (M)XX(CIEXP) X CF X IF 0.905

$\theta_{RM} = T / M$ 59.999

$E = 1.0 + \text{LOG}(PHI) / \text{LOG}(2.0)$ 1.000

CTFU=(CLRM / E)X((θ_{RM} X Z1+0.5)XX(E) -0.5XX(E)) 54.288

CTB=((CLRM/E)X((θ_{RM} X Z3 + 0.5)XX(E) -0.5XX(E))) / Z3 54.288

CIPS=CTB*Z4/Z2 54.288

CRC1 =CTB X R 0.0

PRE-IOC CRC1 =CRC1 X Z6 0.0

POST-IOC CRC1 =CRC1 X (1.0-Z6) 0.0

COIM =DEM OR CTR*Z5/Z2/EYR 0.0

COMMENTS

1977 DATA ENTERED FOR CDCER, CICER, AND DEM WERE 0.023000 0.000050 0.0
COMPOSITE MATERIAL. 6C BAYS - 800 M LONG X 700 M WIDE. DF CALCULATED
IN COMBINATION WITH 1.1.2.1.1, 1.1.6.1.1, 1.1.9.1.1, 1.1.9.1.15 &
1.1.9.1.20

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.1.1.2 SECONDARY STRUCTURE

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|------------|------|----------------|--------------------|----------|-----|-----|
| T= | 985000.000 | 1F= | 0.012296 | CDCER= | 0.182520 | | |
| M= | 5.000000 | UEM= | 0.0 | CDEXP= | 0.511000 | | |
| CF= | 0.700000 | Z1= | 1.000000 | CICER= | 0.118170 | | |
| PHI= | 0.980000 | Z2= | 60.000000 | CIEXP= | 0.355000 | | |
| R= | 0.001111 | Z3= | 62.000000 | BYEAR= | 1979 | | |
| DF= | 0.033333 | Z4= | 60.000000 | Z5= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | KG | SUM TO 1.1.1.1 | \$,MILLIONS | | | |
| CD=CDCER X (T X DF)XX(CDEXP) X CF | | | | 19.906 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X 1F | | | | 0.002 | | | |
| ORM =T / M | | | | 117200.000 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 0.971 | | | |
| CTFU=(CLRM / E)X(ORM X Z1+.5)XX(E) -0.5XX(E) | | | | 154.716 | | | |
| CTB =(CLRM/E)X(ORM X Z3 + 0.5)XX(E) -0.5XX(E) | | | |) / Z3 | | | |
| CIPS=CTB*Z4/Z2 | | | | 137.181 | | | |
| CRC1 =CTB X R | | | | 0.152 | | | |
| PRE-IDC CRC1 =CRC1 X Z6 | | | | 0.0 | | | |
| POST-IDC CRC1 =CRC1 X (1.0-Z6) | | | | 0.152 | | | |
| COEM =OEM OR CTH*Z5/Z2/ENVR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDEXP, CICER, AND OEM WERE 0.156000 0.101000 0.0 | | | | | | | |
| COMBINE SATELLITE QUANTITIES OF 1.1.2.1.2(163000 UNITS) & | | | | | | | |
| 1.1.6.1.2(6000 UNITS), FOR PHI OF & TF CALCULATIONS. | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.1.1.3 MECHANISMS

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|---|------------|------|----------------|--------------------|----------|-------|-----|
| TF= | 70060.0000 | TE= | 0.104401 | CDCER= | 0.182520 | | |
| M= | 110.000000 | UEM= | 0.014999 | CDEXP= | 0.511000 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.000894 | | |
| PHI= | 0.980000 | Z2= | 60.000000 | CIEXP= | 0.950000 | | |
| R= | 0.002222 | Z3= | 64.000000 | BYEAR= | 1979 | | |
| DF= | 0.020000 | Z4= | 60.000000 | Z5= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | KG | SUM TO 1.1.1.1 | \$, MILLIONS | | | |
| CD=CDCER X (T X DF)XX(CDEXP) X CF | | | | 7.396 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 0.008 | | | |
| WRM = T / M | | | | 636.364 | | | |
| E = 1.0 + LOG(PHI) / LOG(2.0) | | | | 0.971 | | | |
| CTFU=(CLRM / E)X((WRM X Z1+0.5)XX(E) -0.5XX(E)) | | | | 4.406 | | | |
| CTB =(CLRM/E)X((WRM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | | 1 / Z3 | | 3.904 | |
| CIPS=CTB*Z4/Z2 | | | | 3.904 | | | |
| CRCI =CTB X R | | | | 0.009 | | | |
| PRE-IOC CRCI =CRCI X Z6 | | | | 0.0 | | | |
| POST-IOC CRCI =CRCI X (1.0-Z6) | | | | 0.009 | | | |
| OUEM =UEM OR CTB*Z5/Z2/ENVR | | | | 0.015 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND OEM WERE 0.156000 0.000764 0.012820 | | | | | | | |
| 110 KG/MECHANISMS. SYSTEMS HAVE SOME DEGREE OF AUTOMATIC OR DIR. MOTION, . | | | | | | | |
| INCLUDING DRIVE MOTORS FOR ROTATION AT ROTARY JOINT (4000 KG), | | | | | | | |
| CABLE TENSION DEVICES (64000 KG), AND DOCKING PORTS (1200 KG) | | | | | | | |

1.1.1.2 CONCENTRATORS

This element concentrates the solar energy onto the solar blanket to increase the energy density on the conversion device. It includes the reflective material and any integral attach points required for mounting. Excluded are tools and support equipment required for deployment and tensioning.

Concentrator membranes are used to reflect the sun onto the solar cell surfaces and obtain a nominal concentration ratio of 2. The concentrator is made of (0.5-mil) aluminized Kapton. The membrane has a mass of 0.018 kg/m^2 and is mounted on the structure using attachments and tensioning devices. Excluded are tools and support equipment required for deployment.

The DDT&E CER (CD) is based on thin sheet aluminum vendor data. The ICI CER for concentrators is based on Rockwell data for Type H Kapton material with an aluminized coating. As concentrator thickness decreases, cost per unit area decreases due to diminished material requirements. At around 25 microns (1 mil), cost reductions are offset by the increased difficulty of processing thin materials after which the overall cost per unit area begins to rise. Rockwell data from Dupont indicates that the cost (1977 dollars) of 0.5 mil concentrator for the SPS would be about \$4.73 per square meter. At increased demand and increased yields, cost could potentially reach \$1.61 per square meter. However, the most likely value, and the value on which the concentrator ICI CER is based, was quoted at \$2.58 per square meter. For the purposes of the CER, this was rounded to \$3.00 (\$3.51—1979 dollars) per square meter to include sensors and mounting attachments and scaled at a slope of .98 to reflect anticipated large array economies.

Range of Data

DDT&E: $100 \text{ m}^2 - 100,000 \text{ m}^2$
ICI: Unlimited

Cost input parameters are shown in Table 1.1.1.2.

ROCKWELL SPS CH-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.1.2 CONCENTRATORS

INPUT PARAMETERS

INPUT COEFFICIENTS

| | | | | | |
|------|------------|------|-----------|--------|----------|
| TF= | 36940000.0 | TF= | 1.000000 | CDCER= | 0.0 |
| M= | 474500.000 | UEM= | 0.0 | COEXP= | 0.0 |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.000004 |
| PHI= | 0.980000 | Z2= | 60.000000 | CIEXP= | 0.950000 |
| R= | 0.001111 | Z3= | 62.000000 | BYEAR= | 1979 |
| DF= | 1.000000 | Z4= | 60.000000 | Z5= | 0.0 |
| | | | | Z6= | 0.0 |

CALCULATED VALUES

SUM

SUM TO 1.1.1

\$, MILLIONS

$$CU = CDCER \times (1 \times DF) \times (COEXP) \times CF$$

0.0

$$CLRM = CICER \times (M) \times (CIEXP) \times CF \times TF$$

0.866

$$E = 1 / M$$

120.000

$$E = 1.0 + \text{LUG}(\text{PHI}) / \text{LUG}(2.0)$$

0.971

$$CTFU = (CLRM / E) \times (1 + 0.5) \times (E) - 0.5 \times (E)$$

93.066

$$CTB = ((CLRM / E) \times (1 + 0.5) \times (E) - 0.5 \times (E))$$

1 / Z3

82.586

$$CIPS = CTB \times 24 / 22$$

82.586

$$CRC1 = CTB \times R$$

0.092

$$\text{PRE-IUC } CRC1 = CRC1 \times Z6$$

0.0

$$\text{POST-IUC } CRC1 = CRC1 \times (1.0 - Z6)$$

0.092

$$CUEM = UEM \text{ OR } CTB \times 25 / 22 / \text{ENYR}$$

0.0

COMMENTS

1977 DATA ENTERED FOR CDCER, CICER, AND UEM WERE
DENSITY = .0181 KG PER SC METER, 120 SEGMENTS

0.0

0.000003

0.0

1.1.1.3 SOLAR BLANKET

This element converts solar energy to electrical energy and provides power to the power distribution and conditioning buses. It includes photovoltaic conversion cells, cover-plates, substrate, electrical interconnects, and any integral attach points required for mounting. Excluded are tools and support equipment required for deployment and tensioning.

Gallium arsenide (GaAs) cells have been selected. The cell consists of GaAs junction with a GaAlAs window, substrate, adhesive, current collectors, and an anti-reflective coating. The solar blanket consists of a Kapton membrane upon which the cells are fastened with a thermo-setting FEP adhesive. Also included in the blanket are the interconnects, thermal coating, attachments/tensioning devices, and sensors.

Historical cost data on solar arrays from previous satellite programs were readily available from the Redstar Data Base and were used to develop the CD CER.

The CD CER was based on solar array historical cost data from the following programs.

- Skylab (OWS)
- Skylab (ATM)
- FRUSA
- SEPS (Est.)

The cost of array structure and mechanisms was not included so that the data would be compatible with the SPS concept of on-orbit structure fabrication and assembly. Although there is a large difference in size between the above arrays and the SPS array, the SPS array will consist of a large number of smaller units. The development fraction (DF) was utilized to normalize the CD cost to reflect cost of only that portion of the total solar array area required to develop the power system.

Due to the rapidly changing technology, historical data is not applicable for use in estimating the SPS solar blanket production cost. The Department of Energy (DOE) has initiated the U.S. Photovoltaic Conversion Program. Two main objectives of this program are to develop by 1990 the technological and industrial capability to produce silicon solar arrays at a price of less than \$500 per peak KWe and to establish by year 2000 the viability of even lower cost (\$100 to \$300 per KWe) and/or more efficient alternatives utilizing novel materials and devices. Since it is generally believed throughout the photovoltaic industry that low cost solar arrays are achievable and dependent on the demand for high production rates and since some progress toward meeting the DOE goal has already been made, it was decided to develop SPS solar array cost estimates on the basis of projected costs rather than historical costs.

Cost estimates for material and production processing (reference Arthur D. Little report of March 1978—Contract NAS9-15294 with NASA/JSC) were considered in the development of investment costs using the materials cost of \$33/m² and

a fabrication cost of $\$34/\text{m}^2$ yielding a total of $\$67/\text{m}^2$ (1977 dollars) for a gallium arsenide solar cell array. This assessment is also consistent with studies completed under Rockwell company sponsored activity based on 1977 prices and assuming 1990 technology.

A cost estimate was extrapolated for multi-bandgap solar cells after completing technical studies and trades of the SPS configuration. GaAlAs/GaInAs cells were researched from published literature and internal Rockwell program development expectations with tabulations as shown in Table 1.1-1 based on a solar array area of 61.2 km^2 . By adding the $\$34/\text{m}^2$ DOE goal for processing (with a complexity factor) the cost of the GaAlAs/GaInAs is projected at $\$76.2/\text{m}^2$ (1977 dollars). These data were escalated to 1979 dollars and used in conjunction with SPS concepts requiring MBG cells.

Range of Data

DDT&E: 10-300 square meters
ICI: Unlimited

Cost estimates for GaAs solar cells used on the Rockwell reference concept are shown in Table 1.1.1.3.

Table 1.1-3. Cost Estimate of Multi-Bandgap Solar Cell

| MATERIAL | AMOUNT REQUIRED (MT) | UNIT COST OF MATERIAL (Ref. 1) | TOTAL COST OF MATERIAL (\$M)* MULTI-BANDGAP SOLAR CELLS GaAlAs/GaInAs |
|--|-------------------------|--|---|
| Gallium | 780 | \$200/kg | 156 |
| Arsenic | 840 | \$100.09/kg (\$45.4/lb) (99.999%) | 84.1 |
| Selenium | 17 kg | \$192/kg (99.999%) | |
| Indium | 26 | \$96.5/kg (\$3/Troy oz.) | 2.5 |
| Silver | 310 | \$159.39/kg (\$72.30/lb) | 49.4 |
| Silica | | | |
| Silicon (MG) | 59,311 | \$1/kg | |
| Silicon (SEG) | 13,162 | \$10/kg | |
| Zinc | 9 kg | \$1170/kg (99.999%) | |
| Aluminum | 100 (For A), 10 (For B) | \$138/kg (99.999%) | 14. |
| Gold Film + Base Metal | | \$1.82/m ² (Ref. 2) | 115.67 |
| Tin | 880 | \$12.21/kg (\$5.54/lb) | 10.8 |
| Al ₂ O ₃ (Sapphire) | 4872 | \$325/kg | 1,583. |
| Copper | 860 | \$1.17/kg (\$0.53/lb) | 1.0 |
| Tellurion | 1650 | \$0.08/kg (\$0.0344/lb) | 0.1 |
| Kapton | 2200 | \$66.14/kg (\$30/lb) (25 μ m Film) | 146. |
| | | | <u>2,162.57</u> |
| | | (Based on Total Array Area of 61.2 km ²) | (\$36.27/m ²) |
| Total Array \$/m ² = Materials + Processing (DOE Goal) | | | *Millions of dollars |
| GaAlAs/GaInAs Array \$/m ² = \$35.3/m ² + (\$34/m ² \times 1.2) = 76.2/m ² (1977 Dollars), = \$89.15/m ² (1979 Dollars) | | | |

REFERENCES:

- (1) Evaluation of Solar Cells and Arrays for Potential Solar Power Satellite Application, ADL, March 31, 1978 (NAS9-15294).
- (2) High Efficiency Thin Film GaAs Solar Cells, R. J. Stirn, JPL. April, 1976 (NSF/RA 760/28).

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ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.1.3 SOLAP BLANKETS

INPUT PARAMETERS

INPUT COEFFICIENTS

| | | | | | |
|------|------------|------|-----------|--------|----------|
| T= | 28470000.0 | TF= | 1.000000 | CDCER= | 0.188838 |
| M= | 18250.0000 | UEM= | 0.0 | CDEXP= | 0.394000 |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.000078 |
| PHI= | 0.940000 | Z2= | 60.000000 | CIEXP= | 1.000000 |
| R= | 0.002222 | Z3= | 64.000000 | BYEAR= | 1979 |
| DF= | 0.005000 | Z4= | 60.000000 | Z5= | 0.0 |
| | | | | Z6= | 0.0 |

CALCULATED VALUES

SG M

SUM TO 1.1.1

\$, MILLIONS

CD=CDCER X (T X DF)XX(CDEXP) X CF 20.254

CLRM=CICER X (M)XX(CIEXP) X CF X TF 1.431

ORM = T / M 1560.000

E = 1.0 + LOG(PHI) / LOG(2.0) 0.986

CTFU=(CLRM / E)X(ORM X Z1+.5)XX(E) -0.5XX(E) 2035.508

CTB = ((CLRM/E)X(ORM X Z3 + 0.5)XX(E) -0.5XX(E)) / Z3 1916.474

CIPS=CTB*Z4/Z2 1916.473

CRC1 = CTB X R 4.258

PRE-IUC CRC1 =CRC1 X Z6 0.0

POST-IUC CRC1 =CRC1 X (1.0-Z6) 4.258

CUCM =UEM OR CTB*Z5/Z2/ENR 0.0

COMMENTS

1977 DATA ENTERED FOR CDCER, CICER, AND UEM WERE 0.161400 0.000067 0.0

DENSITY = 0.2525 KG PER SQ METER, 60 SECTIONS (26 PANELS EACH).

MAJOR DUTCE COMPLETED DURING PRECURSOR ACTIVITY.

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1.1.1.4 POWER DISTRIBUTION AND CONDITIONING (PD&C)

This element includes power feeders, switching and conditioning equipments necessary to deliver power at the required voltage and power levels throughout the satellite. An energy storage system is included, as a power source, to supply minimum power to the various subsystems during eclipse periods. Data buses are not a part of this element as they are included in the information management and control subsystem (WBS No. 1.1.3).

The PD&C system receives power from the solar photovoltaic power generation system and provides for the power conditioning and switching required to deliver the power, through its distribution network, to the satellite power transmission system. Electrical power is transferred from the solar array distribution network through a rotary joint, utilizing slip rings and brushes, to the microwave antenna distribution and conditioning system for the delivery of power at required levels. Life expectancy of the PD&C is 15 years with the exception of power conductors and slip rings which have a longer life.

1.1.1.4.1 Switch Gear and Regulators

Switch gear and regulator functions will:

- Isolate solar array blankets for maintenance work
- Provide voltage regulation of solar array output by selective switching of isolation switch gears
- Control voltage and currents through the IMCS system for short circuit protection
- Prevent large line transients
- Accommodate systematic start-up and shut-down of array during eclipse periods
- Control various loads

Primary switches will be of the Penning cross-field tube design. Functions controlled by these switches will be monitored by the IMCS to determine their status and establish the opening or closing position as required. Basically the switches are held in a closed state during the operational mode. During start-up and shut-down operations, switches will be monitored by the IMCS, and when certain voltage levels are reached, a command signal will open or close switches as needed.

1.1.1.4.2 Low Voltage Converters

Power converters and conditioners transform existing bus voltages to appropriate subsystem voltage(s) required by subsystem loads and output tolerances are based on using interface requirements. Power converters are designed for a GEO mode of operation.

1.1.1.4.3 Conductors and Insulation

Main feeders are sized to minimize combined mass of itself and the solar array mass, considering power requirements, efficiency, and the variation in resistivity with operating temperature. An average transmission efficiency of approximately 94% was used in sizing the conductor. The power distribution system utilizes flat aluminum (6101/T6) feeders where feasible, and round conductors for those subsystems where flat conductors are not feasible.

The CD CER was based on historical cost data obtained from the Redstar Data Base on the following satellite programs.

- DSCS-II
- ATS-F
- OSO-I
- ATS-B
- ATS-A
- ATS-E
- HEAO

The ICI CER was based on preprocessed aluminum material cost data and the use of 6101/T6 aluminum. Differential aluminum inflation between current prices and expected mid 1986 prices was included. Cost data was obtained from the following manufacturers:

- Reynolds Metals
- Alcoa Aluminum
- Amchem Products, Inc.
- The Yoder Company

RANGE OF DATA

DDT&E: 20 to 150 kilograms
ICI: Unlimited

1.1.1.4.4 Slip Rings

The slip ring portion of the rotary joint is included in the PD&C of the Energy Conversion segment. Slip rings consists of an aluminum core with coin silver cladding. The core cross section is 104.9 cm². The slip ring diameter is 6 m with a length of 18.85 m.

Cost data for the slip rings are based upon large ground commercial and military slip rings. Since all but one of the base data slip rings were designed for ground application, it was decided that these data should not be used as a basis for estimating DDT&E costs. It was determined that the data should be used only as a basis for estimating ICI production costs and then only after applying complexity and specification uprating factors. The following factors were applied:

| | |
|-------------------------------|-----|
| Complexity Factor | × 3 |
| Specification Uprating Factor | × 3 |
| Total | × 9 |

The ICI production cost CER was based on data provided by the following manufacturers:

| <u>Manufacturer</u> | <u>Application</u> |
|---------------------|---------------------------------|
| Poly-Scientific | High energy |
| Poly-Scientific | Radar |
| Electro-Tec | Navy destroyer propeller system |
| Electro-Tec | Satellite solar array |
| I.E.C. | Navy shipboard hoist |

Due to the relatively low production rate per year, the tooling factor is assumed to be 1.0.

The DDT&E cost was estimated with a CER developed for secondary structure which consisted of space qualified hardware of approximately the same complexity. See the discussion of the secondary structure CER.

1.1.1.4.5 Batteries

Batteries will be utilized during ecliptic periods to provide minimum energy required by energy conversion subsystems. Batteries will be of a sodium chloride design, having a density of at least 200 watt hours/kg.

DDT&E and the ICI CER's were developed using battery data from manned/unmanned spacecraft list below:

- | | |
|-----------------------|-----------|
| • APOLLO Lunar Module | • ATS-F |
| • APOLLO Lunar Rover | • HAWKEYE |
| • ATS-E | • OSO-I |

RANGE OF DATA

DDT&E: 1.0 to 180.0 kg
ICI: 1.0 to 180.0 kg

1.1.1.4.6 Battery PD&C

This element provides for the charging of satellite batteries and the distribution and regulation of power to and from the batteries. Included are the battery chargers, power regulators, diodes, and power conditioning equipment which directly interface with the battery subsystem. The IMS will be used to monitor and control charging elements.

The DDT&E and the ICI CER's were developed using data from the manned and unmanned spacecraft programs as noted:

- | | |
|-----------------------|-----------|
| • APOLLO Lunar Module | • GEMINI |
| • APOLLO Lunar Rover | • HAWKEYE |
| • ATS-E | • OSI-I |
| • ATS-F | |

RANGE OF DATA

DDT&E: 2.0 to 68.0 kg

ICI: 2.0 to 68.0 kg

1.1.1.4.7 PD&C Cost Estimates

Cost calculations developed for the energy conversion system are presented in the following tables:

| <u>Table</u> | <u>Description</u> |
|--------------|----------------------------|
| 1.1.1.4.1 | Switch Gear and Regulators |
| 1.1.1.4.2 | Low-Voltage Converters |
| 1.1.1.4.3 | Conductors and Insulation |
| 1.1.1.4.4 | Slip Rings |
| 1.1.1.4.5 | Batteries |
| 1.1.1.4.6 | Battery PD&C |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.1.4.1 SWITCH GEAR & REGULATORS - E.C.

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|------------|------|----------------|--------------------|----------|--------|-----|
| T= | 304000.000 | TF= | 1.000000 | CDCER= | 0.184860 | | |
| M= | 195.000000 | DEM= | 0.0 | CDEXP= | 0.297000 | | |
| CF= | 1.200000 | Z1= | 1.000000 | CICER= | 0.000468 | | |
| PHI= | 0.950000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.033333 | Z3= | 120.000000 | BYEAR= | 1979 | | |
| DF= | 0.050000 | Z4= | 60.000000 | Z5= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | Nb | SUM TO 1.1.1.4 | 8, MILLIONS | | | |
| CD=CDCER X (T X DF)XX(CDEXP) X CF | | | | 3.873 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 0.110 | | | |
| ORM =T / M | | | | 1558.974 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 0.926 | | | |
| CTFU=(CLRM / E)X((ORM X Z1+.5)XX(E) -0.5XX(E)) | | | | 106.978 | | | |
| CTB =((CLRM/E)X((ORM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | | 1 / Z3 | | 75.085 | |
| CIPS=CTB*Z4/Z2 | | | | 75.085 | | | |
| CRCI =CTB X R | | | | 2.503 | | | |
| PRE-10C CRCI =CRCI X Z6 | | | | 0.0 | | | |
| PUST-10C CRCI =CRCI X (1.0-Z6) | | | | 2.503 | | | |
| CDEM =DEM OR (CTP*Z5/Z2/ENYR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND DEM WERE 0.158000 0.000400 0.0 | | | | | | | |
| 30 BAYS(60 SECTIONS) WITH 26 SETS PER SECTION OF SWITCH GEAR | | | | | | | |
| EQUIPMENT. 15 YEAR LIFE. | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.1.4.2 LU-VOLTAGE CONVERTERS - E.C.

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|------------|------|----------------|--------------------|----------|-----|-----|
| T= | 9000.00000 | TF= | 1.000000 | CDCER= | 0.184860 | | |
| M= | 5.770000 | UEM= | 0.0 | COEXP= | 0.297000 | | |
| CF= | 1.200000 | Z1= | 1.000000 | CICER= | 0.000468 | | |
| PHI= | 0.980000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.033333 | Z3= | 120.000000 | BYEAR= | 1979 | | |
| DF= | 0.050000 | Z4= | 60.000000 | Z5= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | K6 | SUM TO 1.1.1.4 | \$,MILLIONS | | | |
| CD=CDCER X (V X DF)XX(CIEXP) X CF | | | | 1.362 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 0.003 | | | |
| ORM =1 / M | | | | 1559.792 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 0.971 | | | |
| CTFU=(CLRM / E)X((ORM X Z1+0.5)XX(E) -0.5XX(E)) | | | | 4.202 | | | |
| CTB =((CLRM/E)X((ORM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | | 1 / Z3 | 3.655 | | |
| CIPS=CTB*Z4/Z2 | | | | 3.655 | | | |
| CRC1 =CTB X R | | | | 0.122 | | | |
| PRE-10C CRC1 =CRC1 X Z6 | | | | 0.0 | | | |
| POST-10C CRC1 =CRC1 X (1.0-Z6) | | | | 0.122 | | | |
| COEM =OEM OR CTB*Z5/Z2/ENR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND OEM WERE | | | | 0.158000 | 0.000400 | 0.0 | |
| 30 DAYS (60 SECTIONS) WITH 26 SETS PER SECTION OF CONVERTER EQUIPMENT 15 YEAR LIFE. | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.1.4.3 CONDUCTORS & INSULATION

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|---|------------|------|----------------|--------------------|----------|-----|-----|
| T= | 2395000.00 | TF= | 1.000000 | CDCER= | 0.184860 | | |
| M= | 1535.00000 | UEM= | 0.0 | COEXP= | 0.297000 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.000005 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.0 | Z3= | 60.000000 | RYEAR= | 1979 | | |
| DF= | 0.100000 | Z4= | 60.000000 | Z5= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | K6 | SUM TO 1.1.1.4 | \$, MILLIONS | | | |
| CD=CDCER X (T X DF)XX(COEXP) X CF | | | | 7.320 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 0.007 | | | |
| ORM =1 / M | | | | 1560.260 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 1.000 | | | |
| CTFU=(CLRM / E)X(1+ORM X Z1+0.5)XX(E) -0.5XX(E) | | | | 11.209 | | | |
| CTB =((CLRM/E)X(1+ORM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | | 1 / Z3 11.209 | | | |
| CIPS=CTB*Z4/Z2 | | | | 11.209 | | | |
| CRC1 =CTB X R | | | | 0.0 | | | |
| PRE-IDC CRC1 =CRC1 X Z6 | | | | 0.0 | | | |
| POST-IDC CRC1 =CRC1 X (1.0-Z6) | | | | 0.0 | | | |
| CUEM =UEM OR C16=Z5/Z2/ENVR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND UEM WERE | | | | 0.158000 | 0.000004 | 0.0 | |
| 30 DAYS (60 SECTIONS) WITH 26 SETS PER SECTION. | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.1.4.4 SLIP RINGS

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|---|------------|------|----------------|--------------------|----------|-----|-----|
| T= | 43000.0000 | TF= | 1.000000 | CDCER= | 0.182520 | | |
| M= | 717.000000 | DEM= | 0.0 | CDEXP= | 0.511000 | | |
| CF= | 1.500000 | Z1= | 1.000000 | CICER= | 0.000894 | | |
| PHI= | 0.900000 | Z2= | 60.000000 | CIEXP= | 0.950000 | | |
| R= | 0.005555 | Z3= | 70.000000 | BYEAR= | 1979 | | |
| DF= | 0.020000 | Z4= | 60.000000 | Z5= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | K6 | SUM TO 1.1.1.4 | \$,MILLIONS | | | |
| CD=CDCER X (1 X DF)XX(CDEXP) X CF | | | | 8.648 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 0.692 | | | |
| ORM =T / M | | | | 59.972 | | | |
| E =1.0 + LOG(PHI) / LOG(Z40) | | | | 0.848 | | | |
| CTFU=(CLRM / E)X(ORM X Z1+0.5)XX(E) -0.5XX(E) | | | | 25.999 | | | |
| CTB =(CLRM/E)X(ORM X Z3 + 0.5)XX(E) -0.5XX(E) | | | | 1 / Z3 | 13.766 | | |
| CIPS=CTB*Z4/Z2 | | | | 13.766 | | | |
| CRCI =CTB X R | | | | 0.076 | | | |
| PRE-IUC CRCI =CRCI X Z6 | | | | 0.0 | | | |
| POST-IUC LRCI =CRCI X (1.0-Z6) | | | | 0.076 | | | |
| COEM =DEM OR CTB*Z5/Z2/ENYR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND DEM WERE 30 SLIP RING PAIRS (60 RINGS). | | | | 0.156000 | 0.000764 | 0.0 | |

ROCAWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.1.4.5 BATTERIES

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|------------|------|----------------|--------------------|--------------|-----|-----|
| T= | 4000.00000 | TF= | 0.054480 | CDCER= | 0.040145 | | |
| M= | 50.000000 | DEM= | 0.010850 | COEXP= | 0.734000 | | |
| CF= | 1.200000 | Z1= | 1.000000 | CICER= | 0.030380 | | |
| PHI= | 0.950000 | Z2= | 60.000000 | CIEXP= | 0.241000 | | |
| R= | 0.033333 | Z3= | 120.000000 | BYEAR= | 1979 | | |
| DF= | 0.200000 | Z4= | 60.000000 | Z5= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | KG | SUM TO 1.1.1.4 | | \$, MILLIONS | | |
| CD=CDCER X (T X DF)XX(COEXP) X CF | | | | | 6.511 | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | | 0.005 | | |
| WRM = T / M | | | | | 80.000 | | |
| E = 1.0 + LOG(PHI) / LOG(2.0) | | | | | 0.926 | | |
| CIFU=(CLRM / E)X((WRM X Z1+.5)XX(E) -0.5XX(E)) | | | | | 0.317 | | |
| CTB =((CLRM/E)X((WRM X Z3 + 0.5)XX(E) -0.5XX(E)) | | |) / Z3 | | 0.223 | | |
| CIPS=CTB*Z4/Z2 | | | | | 0.223 | | |
| CRC1 =CTB X R | | | | | 0.007 | | |
| PRE-IUC CRL1 =CRC1 X Z6 | | | | | 0.0 | | |
| POST-IUC CRC1 =CRC1 X (1.0-Z6) | | | | | 0.007 | | |
| COEM =DEM OR CTB*.25/Z2/EMR | | | | | 0.011 | | |

COMMENTS

1978 DATA ENTERED FOR CDCER, CICER, AND DEM WERE 0.037000 0.028000 0.010000
50 KG PER CELL AT 10 CELLS PER BATTERY.
CF ACKNOWLEDGES SODIUM CHLORIDE VS DATA BASE. 15 YEAR LIFE. SEE ALSO
1.1.9.1.11 FOR REFERENCE TO UDTCE.

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.1.4.6 BATTERY PUEC

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|------------|------|-----------|--------------------|--------------|-----|-----|
| T= | 2000.00000 | TF= | 0.154411 | CDCER= | 0.057505 | | |
| M= | 250.000000 | UEM= | 0.0 | COEXP= | 0.890000 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.013020 | | |
| PHI= | 0.450000 | Z2= | 60.000000 | CIEXP= | 0.859000 | | |
| R= | 0.005555 | Z3= | 70.000000 | BYEAR= | 1979 | | |
| DF= | 0.100000 | Z4= | 60.000000 | Z5= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | KG | SUM TU | 1.1.1.4 | \$, MILLIONS | | |
| CU=CDCER X (T X DF)XX(COEXP) X CF | | | | | 6.421 | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | | 0.231 | | |
| E = 1.0 + LOG(PHI) / LOG(2.0) | | | | | 0.926 | | |
| CTFU=(CLRM / E)X((UEM X Z1+0.5)XX(E) -0.5XX(E)) | | | | | 1.677 | | |
| CTB =((CLRM/E)X((UEM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | | 1 / Z3 | 1.247 | | |
| CIPS=CTB*Z4/Z2 | | | | | 1.247 | | |
| CRC1 =CTB X R | | | | | 0.007 | | |
| PRE-10C CRC1 =CRC1 X Z6 | | | | | 0.0 | | |
| POST-10C CRC1 =CRC1 X (1.0-Z6) | | | | | 0.007 | | |
| UEM =UEM OR CTB*Z5/Z2/ENYR | | | | | 0.0 | | |

COMMENTS

1978 DATA ENTERED FOR CDCER, CICER, AND UEM WERE 0.053000 0.012000 0.0
COMBINE SATELLITE QUANTITIES FROM 1.1.2.3.6 (200 UNITS) FOR DF & TF CALCULATIONS

1.1.1.5 THERMAL CONTROL

This element includes any component used to modify the temperature of the energy conversion subsystem components. It includes cold plates, heat transfer and radiator devices as well as insulation, thermal control coatings and finishes. Excluded are paints or finishes applied to components during their manufacturing sequence.

1.1.1.6 MAINTENANCE

This element provides for in-place repair or replacement of components and includes work stations, tracks, access ways, and in situ repair equipment on the energy conversion segment of the satellite.

Maintenance requirements of this element are related to the satellites energy conversion section covering main structure, concentrators, solar blankets, and power distribution/conditioning equipment. Some of the items of maintenance equipment will be common-use items serving the satellite power transmission and interface segment. In these cases, the costs have been apportioned to the related WBS element. Maintenance requirements are listed in Table 1.1.1.6 and costs are presented in Tables 1.1.1.6.1, 1.1.1.6.2 and 1.1.1.6.3.

Table 1.1.1.6. Maintenance Requirements

| WBS NO. | MAINTENANCE ITEM DESCRIPTION | 1.1.1.6 ENERGY CONVERSION |
|-----------|--|------------------------------|
| 1.1.1.6.1 | "Free-Flyers" or Barge for Cargo and Personnel (Common Use Item) | 0.8 Vehicle Utilization |
| 1.1.1.6.2 | Manned Manipulator Module | 1 Vehicle |
| 1.1.1.6.3 | Tracks and Access Ways | 84,000 kg |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.1.6.1 MAINTENANCE - FREE FLYERS

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|------------|------|----------------|--------------------|----------|-----|-----|
| T= | 5000.00000 | TF= | 1.000000 | CDCER= | 0.0 | | |
| M= | 5000.00000 | UEM= | 0.0 | CDEXP= | 0.0 | | |
| CF= | 1.250000 | Z1= | 0.800000 | CICER= | 0.006784 | | |
| PHI= | 0.950000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.005555 | Z3= | 58.000000 | BYEAR= | 1979 | | |
| UF= | 1.000000 | Z4= | 48.000000 | Z5= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | K6 | SUM TO 1.1.1.6 | \$,MILLIONS | | | |
| CU=CDCER X (T X UF)XX(CDEXP) X CF | | | | 0.0 | | | |
| CLR=CICER X (M)XX(CIEXP) X CF X TF | | | | 42.398 | | | |
| ERM =T / M | | | | 1.000 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 0.926 | | | |
| CTFU=(CLR / E)X(ERM X Z1+0.5)XX(E) -0.5XX(E) | | | | 34.279 | | | |
| CTB =((CLR/E)X(ERM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | | 1 / Z3 | 33.758 | | |
| CIPS=CTB*Z4/Z2 | | | | 27.006 | | | |
| CRC1 =CTB X R | | | | 0.188 | | | |
| PRE-10C CRC1 =CRC1 X Z6 | | | | 0.0 | | | |
| POST-10C CRC1 =CRC1 X (1.0-Z6) | | | | 0.188 | | | |
| OEM =OEM OR CTR*Z5/Z2/ENR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND OEM WERE | | | | 0.0 | 0.005798 | 0.0 | |

ROCKWELL SPS CP-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.1.6.2 MANNED MANIPULATOR

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|------------|------|----------------|--------------------|--------------|-----|-----|
| T= | 3000.00000 | TF= | 1.000000 | CDCER= | 0.0 | | |
| M= | 3000.00000 | UEM= | 0.0 | CDEXP= | 0.0 | | |
| CF= | 1.100000 | Z1= | 1.000000 | CICER= | 0.006784 | | |
| PHI= | 0.950000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.005555 | Z3= | 70.000000 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 60.000000 | Z5= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | K6 | SUM TO 1.1.1.6 | | \$, MILLIONS | | |
| CU=CDCER X (T X DF)XX(CDEXP) X CF | | | | | 0.0 | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | | 22.386 | | |
| ORM = T / M | | | | | 1.000 | | |
| E = 1.0 + LOG(PHI) / LOG(2.0) | | | | | 0.926 | | |
| CTFU=(CLRM / E)X(ORM X Z1+.5)XX(E) -0.5XX(E) | | | | | 22.467 | | |
| CTB = ((CLRM/E)X(ORM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | | 1 / Z3 | 17.588 | | |
| CIPS=CTB*Z4/Z2 | | | | | 17.588 | | |
| CRCI =CTB X R | | | | | 0.098 | | |
| PRE-IUC CRCI =CRCI X Z6 | | | | | 0.0 | | |
| POST-IUC CRCI =CRCI X (1.0-Z6) | | | | | 0.098 | | |
| COEN =ORM OR CTB*Z5/Z2/ENR | | | | | 0.0 | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND UEM WERE | | | | 0.0 | 0.005798 | 0.0 | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.1.6.3 TRACKS & ACCESS WAYS

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|------------|------|----------------|--------------------|----------|-----|-----|
| T= | 84000.0000 | IF= | 1.000000 | CDLER= | 0.0 | | |
| M= | 84000.0000 | LEM= | 0.0 | CDEXP= | 0.0 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.000058 | | |
| Phi= | 1.000000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.0 | Z3= | 60.000000 | BYEAR= | 1979 | | |
| DF= | 0.200000 | Z4= | 60.000000 | Z5= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | KG | SUM TO 1.1.1.6 | \$,MILLIONS | | | |
| CU=CDLER X (T X DF)X(CIEXP) X CF | | | | 0.0 | | | |
| CLRM=CICER X (M)X(CIEXP) X CF X IF | | | | 4.914 | | | |
| ORM =T / M | | | | 1.000 | | | |
| E =1.0 + LOG(Phi) / LOG(2.0) | | | | 1.000 | | | |
| CIFU=(CLRM / E)X(ORM X (Z1+.5)X(E) -0.5X(E)) | | | | 4.914 | | | |
| CTB =((CLRM/E)X((ORM X (Z3 + 0.5)X(E) -0.5X(E)) | | | | 1 / Z3 | 4.914 | | |
| CIPS=CTB*Z4/Z2 | | | | 4.914 | | | |
| CRC1 =CTB X R | | | | 0.0 | | | |
| PRE-IOC CRC1 =CRC1 X Z6 | | | | 0.0 | | | |
| POST-IOC CRC1 =CRC1 X (1.0-Z6) | | | | 0.0 | | | |
| COEM =OEM OR CTR*Z5/Z2/ENYR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDLER, CICER, AND OEM WERE | | | | 0.0 | 0.000058 | 0.0 | |

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1.1.2 MW POWER TRANSMISSION

The MW power transmission system receives dc electrical power from the solar array via the interface subsystem. This power is conditioned, converted to microwave energy, and radiated to the ground receiving station. It includes power distribution and conditioning components, dc-to-RF conversion devices, and antenna radiating elements.

Costs in this section cover those of the Rockwell SPS reference antenna structure and subarrays with their klystrons; the power distribution and conditioning system, thermal control, phase reference system, and maintenance requirements. The MW antenna system is illustrated in Figure 1.1-3 and illustrates the basic configuration, including overall dimensions of the selected antenna structural concept.

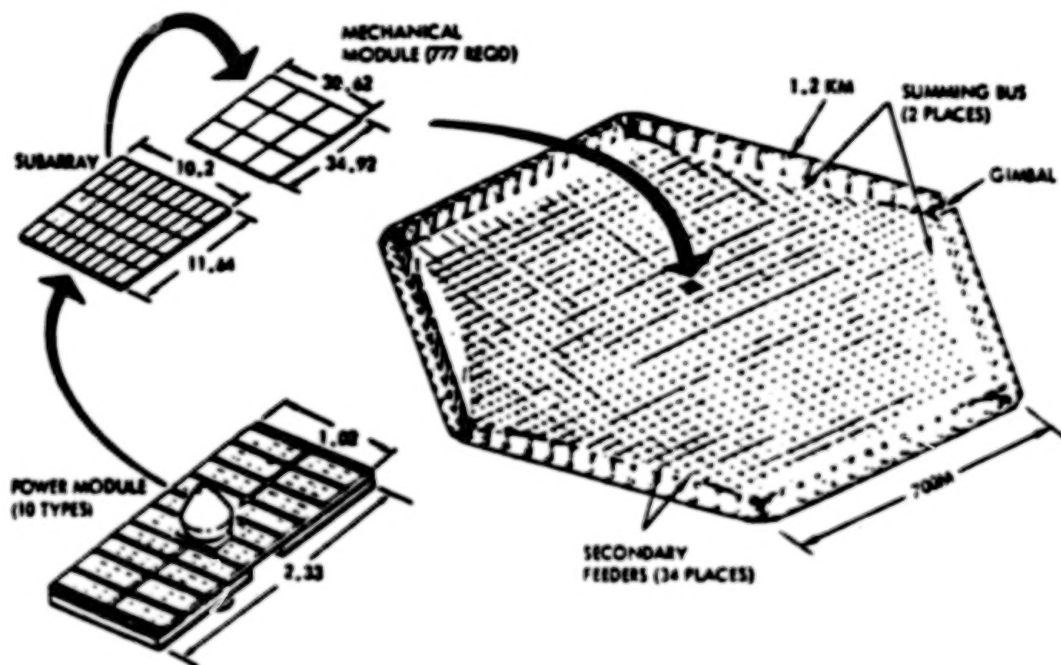


Figure 1.1-3. Microwave Transmission System
—Satellite Antenna

The smallest antenna building block is the power module, which varies in size from the one illustrated (which is used at the center portion of the antenna) to 3.40 by 5.82 meters at the periphery of the antenna. Ten different power module sizes are used to comprise the antenna element. Each power module has a klystron located in its center. The power modules are arranged into subarrays measuring 10.2 by 11.64 meters. Each subarray has its own phase control electronics. Nine subarrays are connected to form a mechanical module 30.82 by 34.92 meters. The tension web antenna is nominally 1200 m in diameter with a 1-km-diameter aperture or active area. The power modules with high power klystrons are mounted on the array structure. The klystrons serve as microwave power amplifiers that beam the MW energy to earth. Table 1.1-5

presents a summary of MPTS and satellite antenna point design characteristics. The basis for this antenna analysis was a transmission capability of 7.14 GW. An assessed maximum klystron output of 52 kW (each) was established.

Table 1.1-5. Point Design Microwave Power Transmission System (MPTS) Satellite Antenna Characteristics

| | |
|--|---------------------|
| <u>MPIS System (Gaussian Beam)</u> | |
| Frequency (GHz) | 2.45 |
| Maximum satellite array power density (kW/m^2) | 21 |
| Power density at ionosphere (mW/cm^2) | 23 |
| MPTS efficiency (includes ionosphere and atmospherics), % | 59.3 |
| DC input power to MPTS from solar array (GW) | 9.94 |
| DC output power to utility (GW) | 5.07 |
| <u>Satellite MPTS Antenna Array</u> | |
| Size (transmitting diameter), km | 1 |
| - Area (km^2) | 0.785 |
| Weight (kg) | 11.98×10^6 |
| Number of mechanical modules | 777 |
| Number of subarrays | 6993 |
| Number of klystron power modules | 142,902 |

1.1.2.1 STRUCTURE

This element includes all members necessary to support transmitter sub-arrays and other power transmission subsystem hardware. It includes structural beams, beam couplers, cables, tensioning devices, secondary structures, and mechanisms. Microwave controlled segments or subarrays are mounted on the hexagonal tension web/compression frame configuration depicted in Figure 1.1-4.

The tension-web/compression-frame antenna structure concept consists of three major elements: (1) the tension web to which dc-to-RF conversion and transmission hardware is attached, (2) a catenary rope system which is attached to the perimeter of the tension web, and (3) a hexagonal compression frame. The tension web resists lateral pressure loading that is transmitted to the vertices of the hexagonal compression frame via the catenary rope system. These frame members are loaded in pure compression and can be analysed as columns. Three of the six catenary-to-compression-frame vertex attachments are fixed. The other three attachments at every other intersection have lateral adjustment jacks. The three fixed attachments describe a plane perpendicular to the desired boresight and the adjustable attachments maintain the tension web as a flat surface. All six catenary rope/compression frame attachments have in-plane tensioning devices that maintain the tension web flat within the design limits. Antenna elevation (north-south) adjustments are accomplished by gimbals in the trunnion structure which attach the antenna to the rotary joint. Azimuth adjustments are made by the rotary joint.

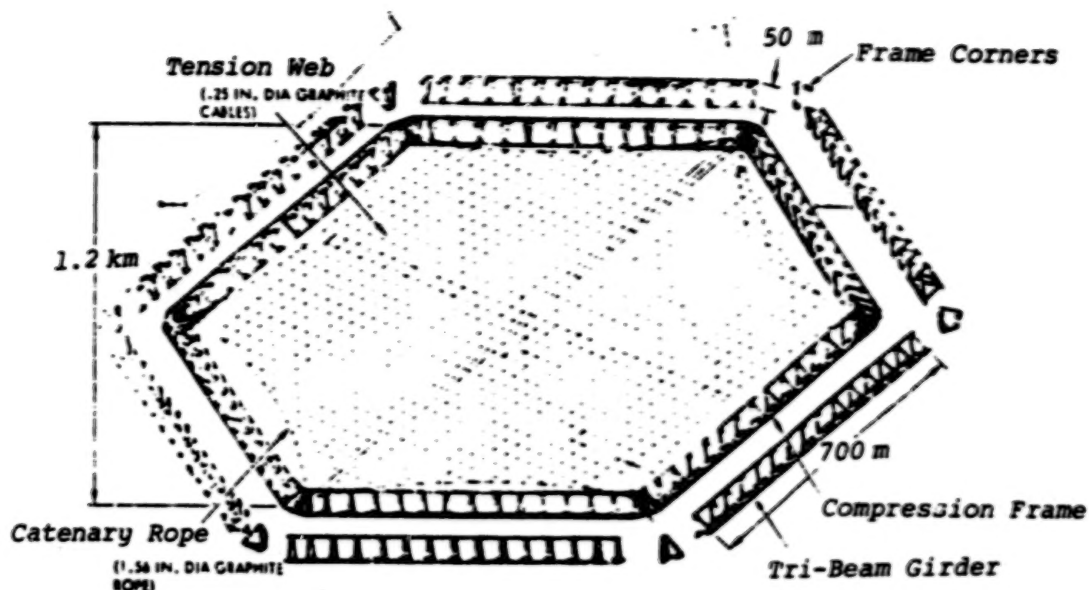


Figure 1.1-4. Microwave Antenna Structure
Selected Design Concept

1.1.2.1.1 Primary Structure

This element consists of the basic supporting framework of the microwave antenna power transmission system up to the interface connection trunnion that has three main components—a tension web made from composite wires or tapes; a catenary cable that transfers the web tension to the vertices; and the octagonal compression frame. The antenna frame provides a structural support but does not include the waveguides or radio frequency assemblies associated with the microwave subsystem.

This element is limited to primary load carrying structure and does not include other secondary structure such as equipment mounts, platforms, and space equipment supports.

The SPS requirement for low thermal distortion, under high thermal stress, dictates the need for a material with a very low coefficient of expansion. The most likely candidate, at this time, is a graphite composite material.

The antenna structure D&D CER was developed using graphite composite data obtained from NASA's Redstar Data Base. Tooling cost was excluded under the assumption that this cost would be incurred in the development of orbital fabrication equipment. The following data points were used:

- Space telescope shell
- HEAO optical bench
- ATS-F truss
- Shuttle payload bay doors

The antenna structure ICI considers the cost of raw materials only since the costs associated with fabrication and assembly are charged against orbital assembly and support equipment (WBS 1.2). The antenna structure ICI cost equation is based on raw composite material stock (prepregnated graphite) cost. These material costs are based on vendor quotes obtained from Hercules, Fibre-rite, and Union Carbide.

Range of Data:

D&D: 30.0 to 2000.0 kg

ICI: Unlimited

1.1.2.1.2 Secondary Structure

Secondary structure consists of passive interface attachments between primary structure and operational subsystems. Structural members are made of aluminum with the ability to articulate, rotate, or otherwise support/allow motion between the primary structure and other system elements.

This element includes all structure, consisting of mounting brackets, clamps and installation structure required as an interface and mounting attachment points of components, assemblies, and subsystems. It also includes any structure required between two or more components or assemblies.

The MSFC CER was used for DDT&E and ICI cost estimates based on cost data contained in the Redstar Data Base. Data from a variety of launch vehicle and unmanned satellite programs were available and the applicable data points are listed below.

- | | |
|--|--|
| • S-IVB interstage | • UV instrument mount assembly (ASM) |
| • S-IC forward skirt | • Solar array and boom structure (ATS-F) |
| • S-IC innertank | • Squib interface unit (ATS-F) |
| • Solar telescope housing assembly (ASM) | • Interstage (Centaur) |
| • Common mount assembly (ASM) | • Fixed airlock shroud (Skylab) |
| • Telescope gimbal assembly (ASM) | • Payload shroud (Skylab) |
| • Common mount actuators (ASM) | • Pallet segment (Spacelab) |
| • Array platform elevation pointing actuator (ASM) | • OSO-1 |
| • UV gimbal mount actuators (ASM) | • ATS-F |
| | • S-II |

Range of Data:

D&D: 6.0 to 15,000.0 kg

ICI: 6.0 to 15,000.0 kg

A review of these data points indicates extrapolations at the 6-kg level were based on the ATS-F solar array and boom structure, the squib interface unit, ASM gimbal assemblies and actuators; whereas the S-IC innertank, Centaur nose shroud, and interstages were extrapolated for the 10,000 kg category. The design and size of these items are considered more complex than that required for the SPS and as a result, a complexity factor (CF) of 0.80 was established for the pilot plant/test article and the COTV. A CF of 0.70 was used for the satellite as the two prior vehicles will be completed and an improved data base will be available for the satellite secondary structure.

Tooling factors were identified by grouping secondary structure requirements for the annual production of satellites (WBS 1.1.1.1.2, Energy Conversion; WBS 1.1.2.1.2, Power Transmission; and WBS 1.1.6.1.2, Interface).

1.1.2.1.3 Mechanisms

This element includes passive components and systems required to support rotation or elevation of the power transmission (antenna) system. Included are bearings and gearing that allow motion of the antenna gimbal to a proper orientation/position.

Operationally, attitude determination system sensors feed signals to the IMS for processing and calculation of pointing commands and the activation of drive motors.

The ICI production cost CER was based on data provided by the following manufacturers:

| Manufacturer | Application |
|-----------------|---------------------------------|
| Poly-Scientific | High energy |
| Poly-Scientific | Radar |
| Electro-Tec | Navy destroyer propeller system |
| Electro-Tec | Satellite solar array |
| I.E.C. | Navy shipboard hoist |

Due to differences in complexity and variations in specification requirements between ground and space-qualified equipment, the following factors were applied:

| | |
|-------------------|-----|
| Complexity factor | × 3 |
| Specification | |
| uprating factor | × 3 |
| Total | × 9 |

Range of Data:

DDT&E: 6.0 to 15,000.0 kg
ICI: 6.0 to 15,000.0 kg

1.1.2.1.4 Cost Estimates

Input parameters T (total) and M (module) are in kilograms of mass. For cost estimates, refer to Tables 1.1.2.1.1, 1.1.2.1.2, and 1.1.2.1.3.

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.2.1.1 PRIMARY STRUCTURE

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|---|------------|------|----------------|--------------------|-----|----------|-----|
| T= | 23000.0000 | TF= | 1.000000 | CD CER= | | 0.026910 | |
| M= | 3834.00000 | UEM= | 0.0 | CD EXP= | | 0.800000 | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | | 0.000058 | |
| PHI= | 1.000000 | Z2= | 60.000000 | CI EXP= | | 1.000000 | |
| R= | 0.0 | Z3= | 60.000000 | BYEAR= | | 1979 | |
| DF= | 0.020000 | Z4= | 60.000000 | Z5= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | R6 | SUM TO 1.1.2.1 | \$ MILLIONS | | | |
| CD=CD CER X (T X DF)XX(CD EXP) X CF | | | | 3.632 | | | |
| CLRM=CICER X (M)XX(CI EXP) X CF X TF | | | | 0.224 | | | |
| #RM =T / M | | | | 5.999 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 1.000 | | | |
| CTFU=(CLRM / E)X((#RM X Z1+.5)XX(E) -0.5XX(E)) | | | | 1.345 | | | |
| CTB =((CLRM/E)X((#RM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | |) / Z3 | | 1.345 | |
| CIPS=CTB*Z4/Z2 | | | | 1.345 | | | |
| CRC1 =CTB X R | | | | 0.0 | | | |
| PRE-IOC CRC1 =CRC1 X Z6 | | | | 0.0 | | | |
| POST-IOC CRC1 =CRC1 X (1.0-Z6) | | | | 0.0 | | | |
| COEM =OEM OR LTH*Z5/Z2/ENYR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CD CER, CICER, AND UEM WERE 0.023000 0.000050 0.0 | | | | | | | |
| HEXAGON STRUCTURE, 1-ENSION WEB DESIGN. DF CALCULATED INCOMBINATION | | | | | | | |
| WITH 1.1.1.1.1, 1.1.0.1.1, & 1.1.9.1.1, 1.1.9.1.15 & 1.1.9.1.20 | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.2.1.2 SECONDARY STRUCTURE

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|------------|------|----------------|--------------------|----------|-----|-----|
| T= | 815000.000 | IF= | 0.012296 | CDCER= | 0.182520 | | |
| M= | 5.000000 | LEM= | 0.0 | CDEXP= | 0.511000 | | |
| CF= | 0.700000 | Z1= | 1.000000 | CICER= | 0.116170 | | |
| PHI= | 0.980000 | Z2= | 60.000000 | CIEXP= | 0.355000 | | |
| R= | 0.001111 | Z3= | 62.000000 | BYEAR= | 1979 | | |
| DF= | 0.033333 | Z4= | 66.000000 | 25= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | KG | SUM TO 1.1.2.1 | \$, MILLIONS | | | |
| CD=CDCER X (T X DF)X(CDEXP) X CF | | | | 23.561 | | | |
| CLRM=CICER X (M)X(CIEXP) X CF X IF | | | | 0.062 | | | |
| FORM = T / M | | | | 163000.000 | | | |
| E = 1.0 + LOG(PHI) / LOG(2.0) | | | | 0.971 | | | |
| CTFU=(CLRM / E)X((FORM X Z1+0.5)X(E) -0.5X(E)) | | | | 213.110 | | | |
| CTB =((CLRM/E)X((FORM X Z3 + 0.5)X(E) -0.5X(E)) | | | 1 / Z3 | 188.962 | | | |
| CIPS=CTB*Z4/Z2 | | | | 188.962 | | | |
| CRC1 =CTB X R | | | | 0.210 | | | |
| PRE-IUC CRC1 =CRC1 X Z6 | | | | 0.0 | | | |
| POST-IUC CRC1 =CRC1 X (1.0-Z6) | | | | 0.210 | | | |
| CGEM =OEM OR CTB*Z5/Z2/ENVR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDEXP, CICER, AND OEM WERE 0.156000 0.101000 0.0 | | | | | | | |
| COMBINE SATELLITE QUANTITIES FROM 1.1.1.1.2(117200 UNITS)& 1.1.6.1.2(16800 UNITS) FOR PHI, DF & IF CALCULATIONS. | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.2.1.3 MECHANISMS (TRUNNIONS)

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | | |
|---|------------|------|----------------|--------------------|----------|-----|-----|-------|
| T= | 2000.00000 | TF= | 1.000000 | CDCER= | 0.182520 | | | |
| M= | 1000.00000 | LEM= | 0.014999 | CDEXP= | 0.511000 | | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.000094 | | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 0.950000 | | | |
| R= | 0.002222 | Z3= | 64.000000 | BYEAR= | 1979 | | | |
| DF= | 1.000000 | Z4= | 60.000000 | Z5= | 0.0 | Z6= | 0.0 | |
| CALCULATED VALUES | | AG | SUM TO 1.1.2.1 | MILLIONS | | | | |
| CD=CDCER X (T X DF)X(CDEXP) X CF | | | | 0.874 | | | | |
| CLRM=CICER X (M)X(CIEXP) X C X TF | | | | 0.633 | | | | |
| ORM = T / M | | | | 2.000 | | | | |
| E = 1.0 + LOG(PHI) / LOG(2.0) | | | | 1.000 | | | | |
| CTFU=(CLRM / E)X(ORM X Z1+0.5)X(E) -0.5X(E) | | | | 1.266 | | | | |
| CTB =((CLRM/E)X(ORM X Z3 + 0.5)X(E) -0.5X(E)) | | | | 1 / Z3 | | | | 1.266 |
| CIPS=CTB*Z4/Z2 | | | | 1.266 | | | | |
| CRC1 =CTB X R | | | | 0.003 | | | | |
| PRE-IOC CRC1 =CRC1 X Z6 | | | | 0.0 | | | | |
| POST-IOC CRC1 =CRC1 X (1.0-Z6) | | | | 0.003 | | | | |
| OEM =OEM OR CTB*Z5/Z2/E*VR | | | | 0.015 | | | | |
| COMMENTS | | | | | | | | |
| 1977 DATA ENTERED FOR CULR, LICH, AND OEM WERE 0.156000 0.000764 0.012820 | | | | | | | | |
| PASSIVE MECHANISMS LOCATED ON ANTENNA - GEAR RING AND BEARINGS. | | | | | | | | |

1.1.2.2 TRANSMITTER SUBARRAYS

This element includes all hardware required for generation, distribution, phase control, and radiation of microwave energy. Systems and components are identified as subarray structure, waveguides, power amplifiers, control devices, and power harnesses. Also included are thermal control devices and finishes manufactured as an integral part of the subarray.

Reference SPS Klystron Concept

RF generators convert direct current (dc) electric power to RF microwave power. Klystrons are used in this system as a high-power RF transmitting device. Waveguides receive the RF power from the generator and radiate it to the ground-based rectenna.

Klystrons with an efficiency of 85.86% are suggested for the Rockwell reference concept microwave power transmitting antenna. The reference klystron is based on the performance of various VKS-773, 50-kW, 2.45-GHz klystrons previously built which obtained an efficiency of 74.4% without a depressed collector. Addition of a depressed collector with 55% beam power recovery efficiency plus other minor design changes will lead to an 80% efficiency. Taking into account cathode heater and solenoid power, a final efficiency of 85% was projected as technologically feasible for the year 1990 and is used in point-design calculations.

Historical cost data for some 20 phased array radars spanning over a period of the last 20 years were extracted from the Redstar Data Base and/or obtained from various contractors. The data were analyzed, normalized, and the costs were adjusted to reflect 1979 dollars. In addition, for all costs utilized, the facility receiver subsystem hardware, data subsystem costs, and basic facility/housing costs were removed.

The application of phased-array radar costs to the development cost estimates of microwave antennas was pertinent since the design and development of these physically large ground installations were conducted in much the same manner as that being utilized for the SPS. Ground array radiating elements were assembled in subarray panels, complete with radiating elements, waveguide, and cabling. Subarrays were then mounted into the facility framework, subarray cabling, and plumbing connection completed at system level, and confidence testing conducted. The same general assembly philosophy is expected to be followed for the SPS microwave antenna, the difference being that the microwave antenna will be totally assembled in the space environment.

The D&D CER was based on data from four DOD classified projects identified only as Projects 21, 22, 23, and 24, as well as the Cobra Dane, AN/SPS-48 and SAM-D (PATRIOT) radar systems.

A different approach was taken to develop TFU CERs. After reviewing the various radar systems' cost it was determined that not enough insight was afforded into the components; therefore, a "grass roots" approach was undertaken.

The microwave power transmission (MWPTS) array for the updated Rockwell reference configuration was analyzed to current design requirements and to reflect 1979 cost projections using the Exhibit C data base. The tension-web antenna is 830,264 m² and required 142,902 power modules with one 52-kW klystron per (LRU) module of 5.8 m² each.

Cost estimates were developed after careful review of MWPTS array subsystems using the MSFC data base, vendor estimates, and cost projections of equipment with similar design characteristics. A 50% allowance was provided for system integration. MPTS instrumentation requirements for voltage control measurements are included as part of Information Management and Control (WBS 1.1.3).

An analysis of klystron microwave system components is summarized in Table 1.1-6. The microwave radiating element (waveguide) is used in conjunction with microwave power generation devices (klystron or magnetron) to radiate this form of energy from a satellite located in GEO to a ground receiving station. A special study was completed to identify possible techniques of manufacturing large quantities of these elements and to project costs for their mass production.

Table 1.1-6. Detail of Rockwell Microwave System Design

| <u>MW System Component</u> | <u>LRU Cost (1979 Dollars)</u> | <u>WBS Reference</u> |
|--|------------------------------------|--------------------------|
| • Waveguide | 348 | 1.1.2.2.2 |
| • Heat pipes (thermal) | 3,006 | 1.1.2.2.3 |
| • Klystron (1 unit/LRU) | 2,340 | 1.1.2.2.4 |
| • Phase shifters | 1,170 | 1.1.2.2.5 |
| • Phase control electronics | 955 | 1.1.2.2.6 |
| • Power dividers and combiners | 152 | 1.1.2.2.7 |
| | 7,971 | |
| • Integration @ 50% | 3,986 | 1.1.2.2.8 |
| LRU cost | 11,957 | |
| LRU's/Antenna | 142,902 | |
| Total estimate/ antenna | \$1709×10 ⁶ | |
| • LRU 5.8 m ² | | |
| • Antenna 830,264 m ² | | |
| • Power modules 142,902 m ² | | |

Techniques considered by Rockwell's Advanced Manufacturing Technology group included dip brazing, fluxless brazing, and adhesive bonding. Although methods of adhesive bonding seem reasonable, it appeared that this technology would need considerable development to meet the 1990 ground rule for availability. The fluxless brazing technique appears as a practical alternative at

this time. A NASA/Langley Research Center contract (NAS1-13382) with Rockwell resulted in the fabrication of an actively cooled panel using this technique, and Rockwell has approximately 15 years of prior experience with this method. Mass production requirements would dictate the use of vacuum furnaces, self-jigging features to hold components, fully automated operation with inspection on a statistical basis, special tooling, and a continuous operation.

Solid-State Array

A cost analysis of the solid-state array for the Rockwell CR-2 planar/dual-mounted antenna configuration is presented in Figure 1.1-5. Electrical power for this microwave array is received from solar panels located on the planar wing of the satellite. Amplifiers used in this configuration represent a high-cost item. System integration and test are reflected at 50% of materials and fabrication.

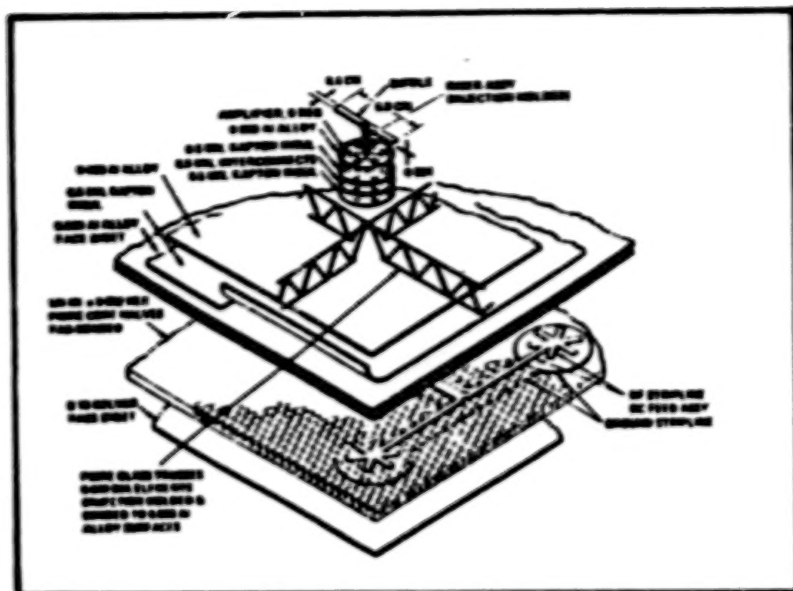
GaAs MBG Sandwich Arrays

Microwave transmission subarrays are "sandwich" designed with integral solar panels on the antennas of satellite configurations using large reflectors. Figure 1.1-6 summarizes cost estimates of this subarray, its solar panel, solid-state devices, amplifiers, and supporting components. These data were used in the costing of Rockwell SPS solid-state sandwich dual antenna/reflector concepts.

Cost Estimates

Table 1.1.2.2.1 expresses DDT&E costs based on antenna power output in kilowatts [$C_D = 0.07839 (P_T)^{0.507} (CF)$]. The following tables cover other cost estimates of the klystron concept.

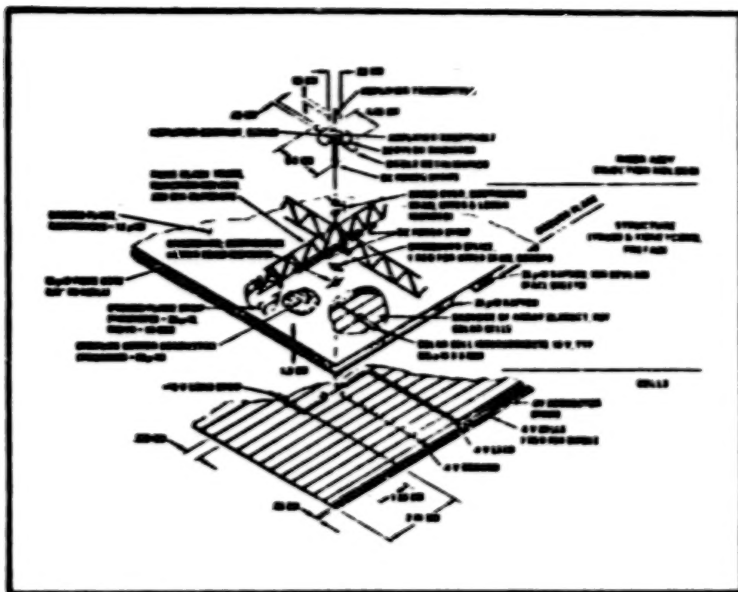
| WBS Table No. | Item |
|---------------|------------------------------|
| 1.1.2.2.2 | Waveguide |
| 1.1.2.2.3 | Heat pipes—thermal |
| 1.1.2.2.4 | Klystron power module |
| 1.1.2.2.5 | Phase shifters |
| 1.1.2.2.6 | Phase control electronics |
| 1.1.2.2.7 | Power dividers and combiners |
| 1.1.2.2.8 | MW system integration |



| ITEM DESCRIPTION | COST/m ² (1979 DOLLARS) |
|---|---------------------------------------|
| MATERIALS & FABRICATION | |
| STRUCTURE | |
| KEVLAR/HONEYCOMB | 16.73 |
| FIBERGLASS TRUSS | 11.87 |
| GROUND PLANE | |
| AL/KAPTON | 9.28 |
| RF STRIPLINE | 3.53 |
| AMPLIFIERS | <u>246.00</u> |
| | 287.41 |
| SYSTEM INTEGRATION & TEST (50%) | <u>143.70</u> |
| TOTAL \$ | 431.11 |

| SINGLE ANTENNA REQUIREMENT | |
|----------------------------|-------------------------------------|
| MASS PER ANTENNA | 5.28×10 ⁶ kg |
| APERTURE | 1350 m |
| ANTENNA AREA | 1.43×10 ⁶ m ² |
| SUBARRAYS/ANTENNA | 14,300 |
| MECHANICAL MODULES | 1589 |
| DIPOLES | 234×10 ⁶ |
| AMPLIFIERS | 1407×10 ⁶ |

Figure 1.1-5. Solid-State Array



| ITEM DESCRIPTION | COST/m ² (1979 DOLLARS) | |
|--------------------------|------------------------------------|--------|
| | GaAs | MBG |
| MATERIALS & FAB. | | |
| STRUCTURE | | |
| KELVAR/HONEYCOMB | 16.73 | 16.73 |
| FIBERGLASS TRUSS | 11.87 | 11.87 |
| GROUND PLANE | | |
| AL/KAPTON | 0.58 | 0.58 |
| RF STRIPLINE | 3.53 | 3.53 |
| BERYLLIUM OXIDE | 15.21 | 28.36 |
| AMPLIFIERS | 41.00 | 82.00 |
| SOLAR PANELS | 78.00 | 89.15 |
| | 166.92 | 232.22 |
| SYS. INTEG. & TEST (50%) | 83.46 | 116.11 |
| TOTAL \$ | 250.38 | 348.33 |

| SINGLE ANTENNA REQUIREMENT | | | | | |
|----------------------------|-----------------------------------|-----------------------------------|----------------|-------------------|-------------------|
| ITEM | GaAs | MBG | ITEM | GaAs | MBG |
| MASS PER ANTENNA | 4.4×10^6 kg | 3.53×10^6 kg | SUBARRAYS/ANT. | 26.300 | 20.867 |
| APERTURE | 1830 m | 1630 m | MECH. MODULES | 2.922 | 2.319 |
| ANTENNA AREA | 2.63×10^6 m ² | 2.09×10^6 m ² | DIPOLES | 431×10^6 | 342×10^6 |
| | | | AMPLIFIERS | 431×10^6 | 684×10^6 |

Figure 1.1-6. GaAs and MBG Sandwich Arrays

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.2.2.1 KLYSTRON MPV & RS DDT&E

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|---|------------|------|-----------|--------------------|----------|--------------|-----|
| T= | 7140000.00 | TF= | 1.000000 | CDCER= | 0.078390 | | |
| M= | 7140000.00 | UEM= | 0.0 | CDEXP= | 0.507000 | | |
| CF= | 1.250000 | Z1= | 1.000000 | CICER= | 0.0 | | |
| PHI= | 0.980000 | Z2= | 60.000000 | CIEXP= | 0.0 | | |
| R= | 0.0 | Z3= | 60.000000 | BYEAR= | 1979 | | |
| DF= | 0.200000 | Z4= | 60.000000 | Z5= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | KN | | SUM TO 1.1.2.2 | | \$, MILLIONS | |
| CU=CDCER X (T X DF)XX(CDEXP) X CF | | | | | | 129.306 | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | | | 0.0 | |
| BRM = T / M | | | | | | 1.000 | |
| E = 1.0 + LOG(PHI) / LOG(2.0) | | | | | | 0.971 | |
| CTFU=(CLRM / E)X((BRM X Z1+.5)XX(E) -0.5XX(E)) | | | | | | 0.0 | |
| CTB =(CLRM/E)X((BRM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | | 1 / Z3 | | 0.0 | |
| CIPS=CTB*Z4/Z2 | | | | | | 0.0 | |
| CRC1 =CTB X R | | | | | | 0.0 | |
| PRE-10C CRC1 =CRC1 X Z6 | | | | | | 0.0 | |
| POST-10C CRC1 =CRC1 X (1.0-Z6) | | | | | | 0.0 | |
| COEM =OEM OR CTB*Z5/Z2/ENVR | | | | | | 0.0 | |

COMMENTS

1979 DATA ENTERED FOR CDCER, CICER, AND OEM WERE 0.078390 0.0 0.0
MSFC CER STRUCTURE. INCLUDES GROUND/SPACE EXPLORATORY DEVELOPMENT FOR ITEMS
WITHIN 1.1.2.2 (TRANSMITTER SUBARRAYS), AND 1.1.2.5 (ANTENNA CONTROL),
OF CONSIDERS PRECURSOR REQUIREMENTS OF POWER TRANSMISSION & RECEPTION.

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ROCKWELL SPS CH-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.2.2.2 WAVE GUIDE

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|------------------|------------|------|-----------|--------------------|----------|-----|-----|
| T= | 142902.000 | TF= | 1.000000 | CDCER= | 0.0 | | |
| M= | 9.000000 | DEM= | 0.0 | CDEXP= | 0.0 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.000348 | | |
| PHI= | 0.980000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.0 | Z3= | 60.000000 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 60.000000 | Z5= | 0.0 | Z6= | 0.0 |

CALCULATED VALUES PM SET SUM TO 1.1.2.2 \$, MILLIONS

CD=CDCER X (T X DF)XX(CDEXP) X CF 0.0

CLRM=CICER X (M)XX(CIEXP) X CF X TF 0.003

ORM = T / M 15878.000

E = 1.0 + LOG(PHI) / LOG(2.0) 0.971

CTFU=(CLRM / E)X(ORM X Z1+0.5)XX(E) -0.5XX(E)) 38.639

CTB =(CLRM/E)X(ORM X Z3 + 0.5)XX(E) -0.5XX(E)) 1 / Z3 34.293

CIPS=CTB*Z4/Z2 34.293

CRC1 =CTB X R 0.0

PRE-IUC CRC1 =CRC1 X Z6 0.0

POST-IUC CRC1 =CRC1 X (1.0-Z6) 0.0

CUEM =UEM OR CTB*Z5/Z2/ENR 0.0

COMMENTS

1979 DATA ENTERED FOR CDCER, CICER, AND UEM WERE 0.0 0.000348 0.0
6993 SUBARRAYS IN 771 MECHANICAL MODULES. 30 YEAR LIFE. 1990 TECHNOLOGY
M CALCULATED AT 9 TYPES OF 142902 POWER MODULE WAVE GUIDES.

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1990
TABLE 1.1.2.2.3 HEAT PIPES -THERMAL

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|---|------------|--------|-----------|--------------------|--------------|-----|-----|
| T= | 142902.000 | Tf= | 1.000000 | CDCEk= | 0.0 | | |
| M= | 9.000000 | DEM= | 0.0 | COEXP= | 0.0 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.003006 | | |
| PHI= | 0.920000 | Z2= | 60.000000 | CIEAP= | 1.000000 | | |
| R= | 0.0 | Z3= | 60.000000 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 60.000000 | Z5= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | PM SET | SUM TO | 1.1.2.2 | \$, MILLIONS | | |
| CD=CDCEK X (T X DF) X (CDEAP) X CF | | | | | 0.0 | | |
| CLRM=CICER X (M) X (CIEAP) X CF X TF | | | | | 0.027 | | |
| EORM = T / M | | | | | 15878.000 | | |
| E = 1.0 + LOG(PHI) / LOG(2.0) | | | | | 0.971 | | |
| CTFU=(CLRM / E) X (EORM X Z1 + 0.5) X (E) - 0.5 X (E) | | | | | 333.757 | | |
| CTB = ((CLRM/E) X (EORM X Z3 + 0.5) X (E) - 0.5 X (E)) | | | | |) / Z3 | | |
| CLPS=CTB*Z4/Z2 | | | | | 296.216 | | |
| CRCI = CTB X R | | | | | 0.0 | | |
| PRE-1UC CRCI =CRCI X Z6 | | | | | 0.0 | | |
| POST-1UC CRCI =CRCI X (1.0-Z6) | | | | | 0.0 | | |
| LOEM =DEM OR CTB*Z5/Z2/ENVR | | | | | 0.0 | | |
| COMMENTS | | | | | | | |
| 1979 DATA ENTERED FOR CDCEK, CICER, AND DEM WERE 0.0 0.003006 0.0 | | | | | | | |
| 8993 SUBARRAYS IN 777 MECHANICAL MODULES. 30 YEAR LIFE. 1990 TECHNOLOGY | | | | | | | |
| WAS CALCULATED ON BASIS OF 9 TYPES OF 142902 POWER MODULE HEAT PIPES. | | | | | | | |
| HEAT PIPE MASS AT 620000 KG | | | | | | | |

ROCKWELL SP2 CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.2.2.4 KLYSTRON POWER MODULE ELEMENT

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|---|------------|--------|----------------|--------------------|----------|-----|-----|
| T= | 142902.000 | IF= | 1.000000 | CDCER= | 0.0 | | |
| M= | 1.000000 | LCM= | 0.0 | CDEXP= | 0.0 | | |
| CF= | 1.250000 | Z1= | 1.000000 | CICER= | 0.002340 | | |
| PHI= | 0.900000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.006667 | Z3= | 72.000000 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 60.000000 | 25= | 0.0 | 26= | 0.0 |
| CALCULATED VALUES | | PM SET | SUM TO 1.1.2.2 | \$,MILLIONS | | | |
| CL=CDCER X (T X DF)X(CDEXP) X CF | | | | 0.0 | | | |
| CLRM=CICER X (M)X(CIEXP) X CF X T | | | | 0.003 | | | |
| ORM =T / M | | | | 142902.000 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 0.971 | | | |
| CTFU=(CLRM / E)X((ORM X Z1+0.5)X(E) -0.5X(E)) | | | | 304.621 | | | |
| CTB =((CLRM/E)X((ORM X Z3 + 0.5)X(E) -0.5X(E))) | | | | 1 / Z3 | 268.920 | | |
| CIPS=CTB*Z4/Z2 | | | | 268.920 | | | |
| CRC1 =CTB X R | | | | 1.793 | | | |
| PRE-10C CRC1 =CRC1 X 25 | | | | 0.0 | | | |
| POST-10C LNC1 =CRC1 X (1.0-26) | | | | 1.793 | | | |
| COEM =OEM OR C15*Z5/Z2/ENVR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1979 DATA ENTERED FOR CDCER, CICER, AND OEM WERE 0.0 0.002340 0.0 | | | | | | | |
| 142902 POWER MODULES IN 643 SUBARRAYS, 1980 TECHNOLOGY. | | | | | | | |
| COMP EXISTY FACTOR OF 1.25 IS USED FOR 92 KW KLYSTRON. | | | | | | | |
| R1= CE CATHODES ONLY EVERY 10 YEARS AT 10% OF KLYSTRON COST ESTIMATE. | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.2.2.5 PHASE SHIFTERS

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|---|------------|--------|----------------|--------------------|----------|-----|-----|
| T= | 142902.000 | TF= | 1.000000 | CDCER= | 0.0 | | |
| M= | 20.434998 | UGM= | 0.0 | CDEXP= | 0.0 | | |
| CF= | 1.250000 | Z1= | 1.000000 | CICER= | 0.001170 | | |
| PHI= | 0.980000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.033334 | Z3= | 120.000000 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 60.000000 | Z5= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | PM SET | SUM TO 1.1.2.2 | \$,MILLIONS | | | |
| CD=CDCER X (T X DF)XX(CDEXP) X CF | | | | 0.0 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 0.030 | | | |
| WRM =T / M | | | | 6993.000 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 0.971 | | | |
| CIFU=(CLRM / E)X((WRM X (1+.5)XX(E) -0.5XX(E)) | | | | 166.307 | | | |
| CTB =((CLRM/E)X((WRM X (1+.5)XX(E) -0.5XX(E)) | | | | 1 / Z3 | 144.651 | | |
| CIPS=CTB*Z4/Z2 | | | | 144.651 | | | |
| CRC1 =CTB X R | | | | 4.822 | | | |
| PRE-IOC CRC1 =CRC1 X Z6 | | | | 0.0 | | | |
| POST-IOC CRC1 =CRC1 X (1.0-Z6) | | | | 4.822 | | | |
| OQM =OQM OR CTB*Z5/Z2/ENYR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1979 DATA ENTERED FOR CDCER, CICER, AND OQM WERE 0.0 0.001170 0.0 | | | | | | | |
| 6993 SUBARRAYS IN 777 MECHANICAL MODULES. 15 YEAR LIFE. 1990 TECHNOLOGY | | | | | | | |

KOCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.2.2.6 PHASE CONTROL ELECTRONICS

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|---|------------|--------|------------|--------------------|-------------|---------|-----|
| T= | 142902.000 | TF= | 1.000000 | CDCER= | 0.0 | | |
| M= | 183.93999H | UGM= | 0.0 | CDEXP= | 0.0 | | |
| CF= | 1.250000 | Z1= | 1.000000 | CICER= | 0.000955 | | |
| PHI= | 0.980000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.033334 | Z3= | 120.000000 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 60.000000 | Z5= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | PM SET | SUM TO | 1.1.2.2 | \$ MILLIONS | | |
| CD=CDCER X (T X DF)XX(CDEXP) X CF | | | | | 0.0 | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | | 0.220 | | |
| θRM =T / M | | | | | 776.979 | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | | 0.971 | | |
| CTFU=(CLRM / E)X((θRM X Z1+0.5)XX(E) -0.5XX(E)) | | | | | 144.703 | | |
| CTB =(1/CLRM/E)X((θRM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | | | 1 / Z3 | 125.878 | |
| CIPS=CTB*Z4/Z2 | | | | | 125.878 | | |
| CRC1 =CTB X R | | | | | 4.196 | | |
| PRE-1UC CRC1 =CRC1 X Z6 | | | | | 0.0 | | |
| POST-1UC CRC1 =CRC1 X (1.0-Z6) | | | | | 4.196 | | |
| COEM =UGM OR CTB*Z5/Z2/ENYR | | | | | 0.0 | | |
| COMMENTS | | | | | | | |
| 1979 DATA ENTERED FOR CDCER, CICER, AND UGM WERE 0.0 0.000955 0.0 | | | | | | | |
| ONE PCE PER MECHANICAL MODULE. | | | | | | | |
| CICER APPORTIONED PER POWER MODULE. 15 YEAR LIFE. | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.2.2.7 POWER DIVIDERS & COMBINERS

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|------------------|------------|------|------------|--------------------|----------|-----|-----|
| T= | 142902.000 | TF= | 1.000000 | CDCER= | 0.0 | | |
| M= | 183.919998 | UEM= | 0.0 | CDEXP= | 0.0 | | |
| CF= | 1.250000 | Z1= | 1.000000 | CICER= | 0.000152 | | |
| PHI= | 0.980000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.033334 | Z3= | 120.000000 | BYEAR= | 1979 | | |
| UF= | 1.000000 | Z4= | 60.000000 | Z5= | 0.0 | Z6= | 0.0 |

CALCULATED VALUES PM SET SUM TO 1.1.2.2 \$, MILLIONS

CD=CDCER X (T X DF)XX(CDEXP) X CF 0.0

CLRM=CICER X (M)XX(CIEXP) X CF X TF 0.035

WRM = T / M 776.979

E = 1.0 + LOG(PHI) / LOG(2.0) 0.971

CTFU=(CLRM / E)X((WRM X Z1+0.5)XX(E) -0.5XX(E)) 23.031

CTB = ((CLRM/E)X((WRM X Z3 + 0.5)XX(E) -0.5XX(E)) 1 / Z3 20.035

CIPS=CTB*Z4/Z2 20.035

CRC1 = CTB X R 0.668

PRE-1UC CRC1 =CRC1 X Z6 0.0

POST-1UC CRC1 =CRC1 X (1.0-Z6) 0.668

CEM =UEM OR CTB*Z5/Z2/ENVR 0.0

COMMENTS

1979 DATA ENTERED FOR CDCER, CICER, AND UEM WERE 0.0 0.000152 0.0

ONE PWR DIVIDERS & COMB PER MECHANICAL MODULE.

CICER APPORTIONED PER POWER MODULE. 15 YEAR LIFE.

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.2.2.8 MM SYSTEM INTEGRATION

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|---|------------|------|----------------|--------------------|----------|-----|-----|
| T= | 142902.000 | IF= | 1.000000 | CDCER= | 0.0 | | |
| M= | 142902.000 | UGM= | 0.0 | COEXP= | 0.0 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.003986 | | |
| PmI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.0 | Z3= | 60.000000 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 60.000000 | Z5= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | LOG | SUM TO 1.1.2.2 | \$, MILLIONS | | | |
| CU=CDCER X (T X DF)XX(COEXP) X CF | | | | 0.0 | | | |
| CLRM=CLICER X (M)XX(CIEXP) X CF X IF | | | | 569.608 | | | |
| WRM =T / M | | | | 1.000 | | | |
| E =1.0 + LOG(PmI) / LOG(2.0) | | | | 1.000 | | | |
| CTFU=(CLRM / E)X((WRM X Z1+.5)XX(E) -0.5XX(E)) | | | | 569.608 | | | |
| CTB =(CLRM/E)X((WRM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | |) / Z3 | | | |
| CIPS=CTB*Z4/Z2 | | | | 569.607 | | | |
| CRC1 =CTB X R | | | | 0.0 | | | |
| PRE-IDC CRC1 =CRC1 X Z6 | | | | 0.0 | | | |
| POST-IDC CRC1 =CRC1 X (1.0-Z6) | | | | 0.0 | | | |
| CUGM =UGM UR CTB*Z5/Z2/ENVR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1979 DATA ENTERED FOR CDCER, CICER, AND UGM WERE | | | | 0.0 | 0.003986 | 0.0 | |
| SYSTEM INTEGRATION OF ITEMS 1.1.2.2.2 THROUGH 1.1.2.2.7 | | | | | | | |

1.1.2.3 POWER DISTRIBUTION AND CONDITIONING (PD&C)

This element includes power feeders, switching, and conditioning equipment necessary to deliver power at the required voltage and power levels for the power transmission section (antenna portion) of the satellite. An energy storage system is included to supply power to keep the power transmission system at a ready state and for housekeeping requirements during eclipse periods. Data buses are not a part of this element as they are included in the information management and control subsystem (WBS 1.1.3).

The PD&C system receives power from the interface (energy conversion/power transmission) system and provides for the power conditioning and switching required to deliver the power, through the distribution network, to microwave energy conversion units. On the rotating member, power is conducted through switch gears to dc/dc converters that produce six primary voltages required by the klystrons. Each voltage is then conducted to a summing bus through switch gears and power feeders and on through switch gear at mechanical modules for use at microwave subarrays to provide power for the 142,902 klystrons. A schematic of the power distribution system on the rotating antenna is shown in Figure 1.1-7 as applicable to the Rockwell reference configuration.

Batteries and battery conditioning equipment provide stored energy to power klystron heaters which keep the tubes in a ready state during eclipse periods. Batteries also provide power for necessary housekeeping activities, i.e., stationkeeping, IMCS, TT&C, etc., during these same eclipses.

The PD&C system has a life expectancy of 15 years with the exception of power conductors.

1.1.2.3.1 Switch Gear and Regulators

Switch gear and regulator functions will:

- Isolate solar array blankets for maintenance work
- Provide voltage regulation of solar array output by selective switching of isolation switch gears
- Control voltage and currents through the IMCS system for short-circuit protection
- Prevent large line transients
- Accommodate systematic startup and shutdown of array during eclipse periods
- Control various loads

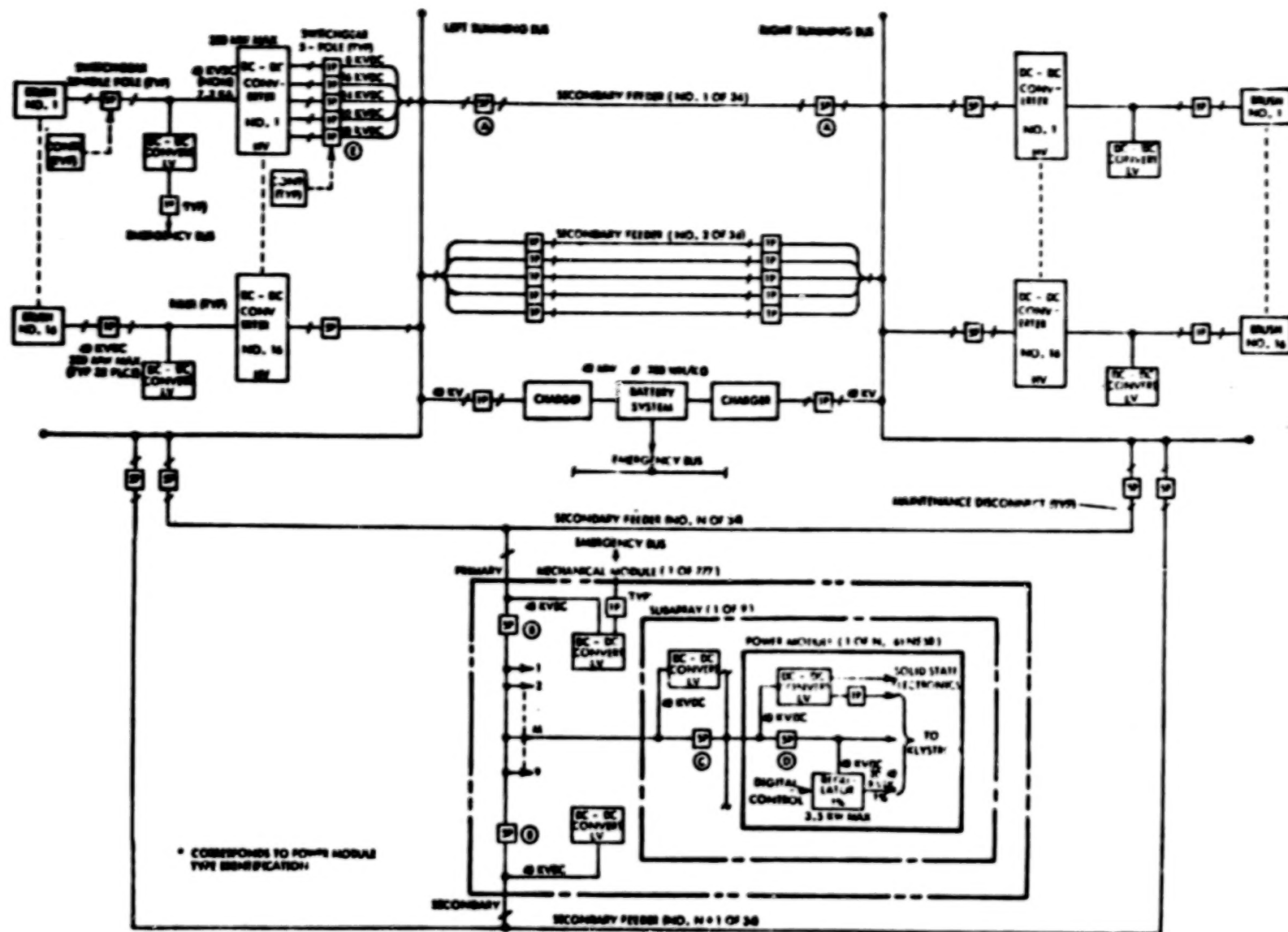


Figure 1.1-7. Microwave Antenna—Power Distribution

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Primary switches will be of the Penning cross-field tube design. Functions controlled by these switches will be monitored by the IMCS to determine their status and establish the opening or closing position as required. Basically, the switches are held in a closed state during the operational mode. During start-up and shutdown operations, switches will be monitored by the IMCS and, when certain voltage levels are reached, a command signal will open or close switches as needed.

1.1.2.3.2 High-Voltage Converters

High-voltage dc-dc power converters/conditioners are used on the klystron concept to transform bus voltages from the array to a level for subsequent use by antenna subsystems.

Magnetron antenna configurations differ from the klystron version in two instances. The first is that high-voltage dc/dc converters are not needed; and second, the distribution system need accommodate only one voltage (20 kV, nominal).

1.1.2.3.3 Low-Voltage Converters

Low-voltage power converters and conditioners transform bus voltages to appropriate subsystem voltage(s) required by subsystems load, and output tolerances are based on using interface requirements. Power converters are designed for a GEO mode of operation.

1.1.2.3.4 Conductors and Insulation

Main feeders are sized to minimize the combined mass of itself and the solar array mass, considering power requirements, efficiency, and the variation in resistivity with operating temperature. An average transmission efficiency of approximately 94% was used in sizing the conductor. The power distribution system utilizes flat aluminum (6106/T6) feeders where feasible, and round conductors for those subsystems where flat conductors are not feasible.

The CD CER was based on historical cost data obtained from the Redstar Data Base on the following satellite programs:

- | | |
|-----------|---------|
| • DSCS-II | • ATS-A |
| • ATS-F | • ATS-E |
| • OSO-I | • HEAO |
| • STS-B | |

The ICI CER was based on preprocessed aluminum material cost data and the use of 6101/T6 aluminum. Differential aluminum inflation between current prices and expected mid 1986 prices was included. Cost data were obtained from the following manufacturers:

- | | |
|-------------------|-------------------------|
| • Reynolds Metals | • Amchem Products, Inc. |
| • Alcoa Aluminum | • The Yoder Company |

Range of Data:

DDT&E: 20 to 150 kg
ICI: Unlimited

1.1.2.3.5 Batteries

Batteries will be utilized during the ecliptic periods to provide minimum energy to keep the klystrons warmed to a ready state and as necessary during required housekeeping tasks. Batteries will be a sodium chloride type having the capability of providing 200 Wh/kg.

DDT&E and the ICI CERs were developed using battery data from manned/unmanned spacecraft listed below.

- Apollo Lunar Module
- Apollo Lunar Rover
- ATS-E
- ATS-F
- Hawkeye
- OSO-I

Range of Data:

DDT&E: 1.0 to 180.0 kg
ICI: 1.0 to 180.0 kg

1.1.2.3.6 Battery PD&C

This element provides for the charging, distribution, and regulation of power to and from the batteries. Included are the battery chargers, power regulators, diodes, and power conditioning equipment which directly interface with the battery subsystem. This function will be monitored and controlled by the IMS.

DDT&E and ICI CERs were developed using data from manned and unmanned spacecraft programs as noted:

- Apollo Lunar Module
- Apollo Lunar Rover
- ATS-E
- ATS-F
- Gemini
- Hawkeye
- OSO-I

Range of Data:

DDT&E: 2.0 to 68.0 kg
ICI: 2.0 to 68.0 kg

1.1.2.3.7 PD&C Cost Estimates

Cost calculations developed for the antenna are presented in the following tables:

| Table | Description | Table | Description |
|-----------|----------------------------|-----------|---------------------------|
| 1.1.2.3.1 | Switch gear and regulators | 1.1.2.3.4 | Conductors and insulation |
| 1.1.2.3.2 | High-voltage converters | 1.1.2.3.5 | Batteries |
| 1.1.2.3.3 | Low-voltage converters | 1.1.2.3.6 | Battery PD&C |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.2.3.1 SWITCH GEAR & REGULATORS

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|---|------------|------|----------------|--------------------|----------|-----|-----|
| T= | 343000.000 | TF= | 1.000000 | CDCER= | 0.184860 | | |
| M= | 49.000000 | CEM= | 0.0 | CDEXP= | 0.297000 | | |
| CF= | 1.200000 | Z1= | 1.000000 | CICER= | 0.000468 | | |
| PHI= | 0.950000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.033333 | Z3= | 120.000000 | BYEAR= | 1979 | | |
| UF= | 0.050000 | Z4= | 60.000000 | Z5= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | KG | SUM TO 1.1.2.3 | \$,MILLIONS | | | |
| CD=CDCER X (T X UF)XX(CDEXP) X CF | | | | 4.014 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 0.028 | | | |
| FORM =T / M | | | | 7000.000 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 0.926 | | | |
| CTFU=(CLRM / E)X((FORM X Z1+.5)XX(E) -0.5XX(E)) | | | | 108.028 | | | |
| CTB =((CLRM/E)X((FORM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | 1 / Z3 | 75.807 | | | |
| CIPS=CTB*Z4/Z2 | | | | 75.807 | | | |
| CRC1 =CTB X R | | | | 2.527 | | | |
| PRE-IUC CRC1 =CRC1 X Z6 | | | | 0.0 | | | |
| POST-IUC CRC1 =CRC1 X (1.0-Z6) | | | | 2.527 | | | |
| CEM =CEM OR CTB*Z5/Z2/ENR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND CEM WERE 0.158000 0.000400 0.0 | | | | | | | |
| 6993 SUBARRAYS. 343000 KG FUP 142902 SWITCHES & REGULATORS. 15 YEAR LIFE. | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.2.3.2 HI-VOLTAGE CONVERTERS

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|---|------------|------|----------------|--------------------|----------|-----|-----|
| T= | 1334000.00 | TF= | 1.000000 | CDLER= | 0.184860 | | |
| M= | 191.000000 | UEM= | 0.0 | CDEXP= | 0.297000 | | |
| CF= | 1.200000 | Z1= | 1.000000 | CICLR= | 0.000243 | | |
| PHI= | 0.980000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.033333 | Z3= | 120.000000 | BYEAR= | 1979 | | |
| DF= | 0.100000 | Z4= | 60.000000 | Z5= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | KG | SUM TO 1.1.2.3 | \$,MILLIONS | | | |
| CU=CDLER X (T X DF)XX(CDEXP) X CF | | | | 7.382 | | | |
| CLRM=CICLR X (M)XX(CIEXP) X CF X TF | | | | 0.056 | | | |
| ORM =T / M | | | | 6984.293 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 0.971 | | | |
| CTFU=(CLRM / E)X(ORM X Z1+0.5)XX(E) -0.5XX(E) | | | | 310.012 | | | |
| CTB =((CLRM/E)X(ORM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | | 1 / Z3 | 269.643 | | |
| LIPS=CTB*Z4/Z2 | | | | 269.643 | | | |
| CRCI =CTB X R | | | | 8.988 | | | |
| PRE-IUC CRCI =CRCI X Z6 | | | | 0.0 | | | |
| POST-IUC CRCI =CRCI X (1.0-Z6) | | | | 8.988 | | | |
| COEM =UEM OR CTH*Z5/Z2/E*YR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDLER,CLCLR, AND UEM WERE C.158000 0.000208 0.0 | | | | | | | |
| 6993 SUBARRAYS. 1334000 KW AT .197 KG/KW RATIO. 15 YEAR LIFE. | | | | | | | |

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ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.2.3.3 LO-VOLTAGE CONVERTERS

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|------------|------|----------------|--------------------|----------|-------|-----|
| T= | 3000.00000 | TF= | 1.000000 | CDCER= | 0.184860 | | |
| M= | 0.400000 | UEM= | 0.0 | CDEXP= | 0.297000 | | |
| CF= | 1.200000 | Z1= | 1.000000 | CICER= | 0.000468 | | |
| PHI= | 0.980000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.033333 | Z3= | 120.000000 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 60.000000 | Z5= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | KG | SUM TO 1.1.2.3 | \$,MILLIONS | | | |
| CD=CDCER X (T X DF)XX(CDEXP) X CF | | | | 2.392 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X IF | | | | 0.000 | | | |
| WRM =T / M | | | | 7500.000 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 0.971 | | | |
| CTFU=(CLRM / E)X((WRM X Z1+.5)XX(E) -0.5XX(E)) | | | | 1.338 | | | |
| CTB =((CLRM/E)X((WRM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | |) / Z3 | | 1.164 | |
| LIPS=CTB*Z4/Z2 | | | | 1.164 | | | |
| CRCI =CTB X R | | | | 0.039 | | | |
| PRE-IUC CRCI =CRCI X Z6 | | | | 0.0 | | | |
| POST-IUC CRCI =CRCI X (1.0-Z6) | | | | 0.039 | | | |
| CDEM =UEM OR CTR*Z5/Z2/ENYR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND UEM WERE 0.158000 0.000400 0.0 | | | | | | | |
| 6993 SUBARRAYS. 3000 KG AT 1 KG/KW RATIO. 15 YEAR LIFE | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 2.1.2.3.4 CONDUCTORS & INSULATION

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|------------|------|----------------|--------------------|----------|-----|-----|
| T= | 773000.000 | TF= | 1.000000 | CDCER= | 0.184860 | | |
| M= | 110.000000 | UEM= | 0.0 | CDEXP= | 0.297000 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.000005 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.0 | Z3= | 60.000000 | BYEAR= | 1979 | | |
| DF= | 0.100000 | Z4= | 60.000000 | Z5= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | KG | SUM TO 1.1.2.3 | \$,MILLIONS | | | |
| CU=CDCER X (T X DF)XX(CDEXP) X CF | | | | 5.232 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 0.001 | | | |
| WRM =T / M | | | | 7027.270 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 1.000 | | | |
| CTFU=(CLRM / E)X(1WRM X Z1+.5)XX(E) -0.5XX(E)) | | | | 3.616 | | | |
| CTB =((CLRM/E)X(1WRM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | 1 / Z3 | 3.618 | | | |
| CIPS=CTB*Z4/Z2 | | | | 3.618 | | | |
| CRCI =CTB X R | | | | 0.0 | | | |
| PRE-IOC CRCI =CRCI X Z6 | | | | 0.0 | | | |
| POST-IOC CRCI =CRCI X (1.0-Z6) | | | | 0.0 | | | |
| COEM =OEM OR CTR*Z5/Z2/ENR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CULER, CICER, AND UEM WERE | | | | 0.158000 | 0.000004 | 0.0 | |
| 777 MECHANICAL MODULES, 6993 SUBARRAYS. | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.2.3.5 BATTERIES

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|------------|------|----------------|--------------------|--------------|-----|-----|
| T= | 200000.000 | TF= | 0.054480 | CDCER= | 0.0 | | |
| M= | 50.000000 | UEM= | 0.542500 | CDEXP= | 0.0 | | |
| CF= | 1.500000 | Z1= | 1.000000 | CICER= | 0.030380 | | |
| PHI= | 0.450000 | Z2= | 60.000000 | CIEXP= | 0.241000 | | |
| R= | 0.033333 | Z3= | 120.000000 | BYEAR= | 1979 | | |
| DF= | 0.200000 | Z4= | 60.000000 | 25= | 0.0 | 26= | 0.0 |
| CALCULATED VALUES | | KG | SUM TO 1.1.2.3 | | \$, MILLIONS | | |
| CD=CDCER X (T X DF)X(CDEXP) X CF | | | | | 0.0 | | |
| CLRM=CICER X (M)X(CIEXP) X CF X TF | | | | | 0.006 | | |
| FORM = T / M | | | | | 4000.000 | | |
| E = 1.0 + LOG(PHI) / LOG(2.0) | | | | | 0.926 | | |
| CIFU=(CLRM / E)X((FORM X Z1+.5)X(E) -0.5X(E)) | | | | | 14.901 | | |
| CTB =(CLRM/E)X((FORM X Z3 + 0.5)X(E) -0.5X(E)) | | |) / Z3 | | 10.457 | | |
| CIPS=CTB*Z4/Z2 | | | | | 10.457 | | |
| CRC1 =CTB X R | | | | | 0.349 | | |
| PRE-IUC CRC1 =CRC1 X Z6 | | | | | 0.0 | | |
| POST-IUC CRC1 =CRC1 X (1.0-Z6) | | | | | 0.349 | | |
| UEM =UEM UR CTR*Z5/Z2/ENYR | | | | | 0.543 | | |

COMMENTS

1978 DATA ENTERED FOR CDCER, CICER, AND UEM WERE 0.0 0.028000 0.500000
TF & DF CALCULATED BY COMBINING QUANTITIES FROM 1.1.1.4.4 (80 CELLS)
50 KG PER CELL AT 10 CELLS PER BATTERY. CF ACKNOWLEDGE SODIUM CHLORINE
TECHNOLOGY. 15 YEAR LIFE. SEE 1.1.1.4.5 FOR DDTCE

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.2.3.6 BATTERY PEG

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|---|------------|------|----------------|--------------------|----------|--------|-----|
| T= | 50000.0000 | TF= | 0.154410 | CDCER= | 0.057505 | | |
| M= | 250.000000 | DEM= | 0.0 | CDEXP= | 0.890000 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.013020 | | |
| PHI= | 0.950000 | Z2= | 60.000000 | CIEXP= | 0.859000 | | |
| R= | 0.005555 | Z3= | 70.000000 | BYEAR= | 1979 | | |
| DF= | 0.005000 | Z4= | 60.000000 | Z5= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | K | SUM TO 1.1.2.3 | \$, MILLIONS | | | |
| CD=CDCER X (T X DF)XX(CDEXP) X CF | | | | 7.832 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 0.231 | | | |
| ERM =T / M | | | | 200.000 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 0.926 | | | |
| CTFU=(CLRM / E)X((ERM X Z1+.5)XX(E) -0.5XX(E)) | | | | 33.618 | | | |
| CTB =((CLRM/E)X((ERM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | |) / Z3 | | 24.587 | |
| CIPS=CTB*Z4/Z2 | | | | 24.587 | | | |
| CRC1 =CTB X R | | | | 0.137 | | | |
| PRE-IDC CRC1 =CRC1 X Z6 | | | | 0.0 | | | |
| POST-IDC CRC1 =CRC1 X (1.0-Z6) | | | | 0.137 | | | |
| COEM =DEM OR C16*Z5/Z2/ENVR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1978 DATA ENTERED FOR CDCER, CICER, AND DEM WERE 0.053000 0.012000 0.0 | | | | | | | |
| COMBINE SATELLITE QUANTITIES FROM 1.1.1.4.5 (8 UNITS) FOR TFEED CALCULATIONS. | | | | | | | |

1.1.2.4 THERMAL CONTROL

This element includes any component used to modify the temperature of power transmission subsystem components. It includes coldplates, heat transfer, and radiator devices as well as insulation, thermal control coatings and finishes. Excluded are paints and finishes applied to components during their manufacturing sequence, and thermal control devices that are an integral part of another component or system.

Multi-layer insulation panels are required on back surfaces of klystron waveguides to restrict waste heat leaks which could increase temperatures of electronics to unacceptable levels. This insulation is coated externally with low absorptivity/emissivity materials to limit affect of absorbed solar flux to which the surface is exposed during part of the orbit.

CERs for insulation are based upon secondary structure CERs where the CERs were considered somewhat comparable to the requirements and application of insulation on the antenna.

Table 1.1.2.4 presents cost estimates for thermal control.

ROCKWELL SPS CH-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.2.4 THERMAL CONTROL - INSULATION

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|------------|------|--------------|--------------------|----------|---------|-----|
| T= | 100000.000 | TF= | 0.015694 | CDCER= | 0.182520 | | |
| M= | 0.700000 | UEM= | 0.0 | CDEXP= | 0.511000 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.118170 | | |
| PHI= | 0.960000 | Z2= | 60.000000 | CIEXP= | 0.355000 | | |
| R= | 0.0 | Z3= | 60.000000 | BYEAR= | 1979 | | |
| DF= | 0.050000 | Z4= | 60.000000 | Z5= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | KG | SUM TO 1.1.2 | 3, MILLIONS | | | |
| CD=CDCER X (T X DF)XX(CDEXP) X CF | | | | 14.174 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 0.002 | | | |
| ORM =T / M | | | | 142857.125 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 0.971 | | | |
| CTFU=(CLRM / E)X((ORM X Z1+0.5)XX(E) -0.5XX(E)) | | | | 170.118 | | | |
| CTB =((CLRM/E)X((ORM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | |) / Z3 | | 150.982 | |
| CIPS=CTB*Z4/Z2 | | | | 150.982 | | | |
| CRC1 =CTB X R | | | | 0.0 | | | |
| PRE-IOC CRC1 =CRC1 X Z6 | | | | 0.0 | | | |
| POST-IOC CML1 =CRC1 X (1.0-Z6) | | | | 0.0 | | | |
| COEM =UEM OR CTB*Z5/Z2/ENYR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND UEM WERE | | | | 0.156000 | 0.101000 | 0.0 | |
| 142902 KLYSTRON UNITS. | | | | | | | |

1.1.2.5 CONTROL-PHASE REFERENCE

This element comprises reference phase electronics for all subarray phase-conjugating circuits consisting of reference oscillator signal distribution and frequency conversion equipment, plus components and equipment that commonly serve all subarrays.

The transmitted signal is formed from the pilot beam by means of retro-electronics where one circuit is required per subarray. A servo system is needed to transfer the required reference phase from a central point to a mechanical module, where it is distributed to the subarrays. Main items included in this subsystem are shown in Table 1.1.2.5

Table 1.1.2.5 Control-Phase Reference

| WBS NO. | ITEM/ DESCRIPTION | QUANTITY PER SATELLITE |
|-----------|--|--|
| 1.1.2.5.1 | REFERENCE FREQUENCY GENERATOR | 1 SET (777 POWER AMPLIFIERS, 1-4 REGULATORS) |
| 1.1.2.5.2 | COAX CABLE | 777 SETS |
| 1.1.2.5.3 | DEVICES FOR USE ON FREQUENCY DISTRIBUTION SYSTEM | 777 SETS |

Tables 1.1.2.5.1, 1.1.2.5.2, and 1.1.2.5.3 present the engineering estimates for these items.

BUCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.2.5.1 REFERENCE FREQUENCY GENERATOR

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|----------|------|----------------|--------------------|----------|-----|-----|
| T= | 1.000000 | TF= | 1.000000 | CDCER= | 0.585000 | | |
| M= | 1.000000 | UEM= | 0.011700 | COEXP= | 1.000000 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.117000 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.033333 | Z3= | 120.000000 | RYEAR= | 1979 | | |
| DF= | 0.200000 | Z4= | 60.000000 | Z5= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | SET | SUM TO 1.1.2.5 | \$, MILLIONS | | | |
| CD=CDCER X (T X DF)X(COEXP) X CF | | | | 0.117 | | | |
| CLRM=CICER X (M)X(CIEXP) X CF X TF | | | | 0.117 | | | |
| QRM = T / M | | | | 1.000 | | | |
| E = 1.0 + LOG(PHI) / LOG(12.0) | | | | 1.000 | | | |
| CTFU=(CLRM / E)X(1+QRM X Z1+0.5)X(E) -0.5X(E) | | | | 0.117 | | | |
| CTB = ((CLRM/E)X(1+QRM X Z3 + 0.5)X(E) -0.5X(E)) | | | 1 / Z3 | 0.117 | | | |
| CIPS=CTB*Z4/Z2 | | | | 0.117 | | | |
| CRC1 =CTB X R | | | | 0.004 | | | |
| PRE-IUC CRC1 =CRC1 X Z6 | | | | 0.0 | | | |
| POST-IUC CRC1 =CRC1 X (1.0-Z6) | | | | 0.004 | | | |
| COEM =DEM OR CTB*Z5/Z2/ENVR | | | | 0.012 | | | |

COMMENTS

1977 DATA ENTERED FOR CDCER, CICER, AND UEM WERE 0.500000 0.100000 0.010000
ENGINEERING ESTIMATE BASED ON DESIGN DEFINITION, 15 YEAR LIFE.

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.2.5.2 DIST. SYSTEM, COAXIAL CABLE

INPUT PARAMETERS

INPUT COEFFICIENTS

| | | | | | |
|------|------------|------|-----------|--------|----------|
| T= | 600000.000 | TF= | 1.000000 | CDCER= | 0.000006 |
| M= | 261.000000 | DEM= | 0.0 | CDEXP= | 1.000000 |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.000070 |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 1.000000 |
| R= | 0.0 | Z3= | 60.000000 | RYEAR= | 1979 |
| DF= | 0.200000 | Z4= | 60.000000 | Z5= | 0.0 |
| | | | | Z6= | 0.0 |

CALCULATED VALUES

M

SUM TO 1.1.2.5

\$, MILLIONS

CD=CDCER X (T X DF)X(CDEXP) X CF 0.702

CLRM=CICER X (M)X(CIEXP) X CF X TF 0.018

B-113 $\theta_{RM} = T / M$ 2298.850

E = 1.0 + LOG(PHI) / LOG(2.0) 1.000

CTFU=(CLRM / E)X((θ_{RM} X Z1 + 0.5)X(E) - 0.5X(E)) 42.120

CTB = ((CLRM/E)X((θ_{RM} X Z3 + 0.5)X(E) - 0.5X(E))) / Z3 42.120

CIPS=CTB*Z4/Z2 42.120

CRC1 = CTB X R 0.0

PRE-IOC CRC1 = CRC1 X Z6 0.0

POST-IOC CRC1 = CRC1 X (1.0-Z6) 0.0

CUSH = DEM OR CTB*Z5/Z2/ENYR 0.0

COMMENTS

1977 DATA ENTERED FOR CDCER, CICER, AND DEM WERE 0.000005 0.000060 0.0
ESTIMATE OF 50 KG PER KM AT 30000 KG EQUALS 600 KM OF LIGHT WEIGHT,
SHIELDED, AND RADIATION RESISTANT COAX.

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.2.5.3 DIST. SYSTEM, DEVICES

INPUT PARAMETERS

INPUT COEFFICIENTS

| | | | | | |
|------|------------|------|------------|--------|----------|
| T= | 1554.00000 | TF= | 1.000000 | EDGER= | 0.000263 |
| M= | 2.000000 | UEM= | 0.0 | CDEXP= | 1.000000 |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.005850 |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 1.000000 |
| R= | 0.033333 | Z3= | 120.000000 | BYEAR= | 1979 |
| DF= | 0.200000 | Z4= | 60.000000 | Z5= | 0.0 |
| | | | | Z6= | 0.0 |

CALCULATED VALUES

SET

SUM TO 1.1.2.5

\$, MILLIONS

CD=CDER X (T X DF)XX(CDEXP) X CF

0.082

CLRM=CICER X (M)XX(CIEXP) X CF X TF

0.012

WRM = T / M

777.000

E = 1.0 + LOG(PHI) / LOG(2.0)

1.000

CTFU=(CLRM / E)X(WRM X Z1+0.5)XX(E) -0.5XX(E)

9.091

CTB =(1/CLRM/E)X(WRM X Z3 + 0.5)XX(E) -0.5XX(E)

1 / Z3

9.091

CIPS=CTB*Z4/Z2

9.091

CRC1 =CTE X R

0.303

PHE=IOC CRC1 =CRC1 X Z6

0.0

PUST=IOC CRC1 =CRC1 X (1.0-Z6)

0.303

CUEM =UEM OR CTB*Z5/Z2/ENYR

0.0

COMMENTS

1977 DATA ENTERED FOR CDLER, CICER, AND UEM WERE
ENGINEERING ESTIMATE.

0.000225

0.005000

0.0

1.1.2.6 MAINTENANCE

This element provides for in-place repair or replacement of components and includes work stations, tracks, access ways, and *in situ* repair equipment.

Maintenance requirements of this element are related to the power transmission (antenna) section of the satellite covering structures, subarrays (klystrons), power distribution/conditioning and energy storage, thermal control, and control elements. Some maintenance equipment is multi-purpose and, therefore, costed against applicable maintenance items on an apportioned basis.

Maintenance requirements for this element are presented in Table 1.1.2.6. Cost estimates are detailed in Tables 1.1.2.6.1, 1.1.2.6.2, 1.1.2.6.3, and 1.1.2.6.4.

Table 1.1.2.6. Maintenance Requirements

| WBS NO. | MAINTENANCE ITEM DESCRIPTION | 1.1.2.6 POWER TRANSMISSION |
|-----------|--|----------------------------|
| 1.1.2.6.1 | "FREE-FLYERS" OR BARGE FOR CARGO AND PERSONNEL (COMMON USE ITEM) | 1 VEHICLE UTILIZATION |
| 1.1.2.6.2 | GANTRY CRANE AT ANTENNA | SET |
| 1.1.2.6.3 | ON-CRANE CONTROL CENTER, HOISTS, EQUIPMENT TEST GEAR, ROBOTICALS | SET |
| 1.1.2.6.4 | TRACKS AND ACCESSWAYS | 12000 kg |

ROCKWELL SPS CH-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.2.6.1 MAINTENANCE - FREE FLYERS

INPUT PARAMETERS

INPUT COEFFICIENTS

| | | | | | |
|------|------------|------|-----------|--------|----------|
| T= | 5000.00000 | IF= | 1.000000 | CDCER= | 0.0 |
| M= | 5000.00000 | UEM= | 0.0 | CDEXP= | 0.0 |
| CF= | 1.250000 | Z1= | 1.000000 | CICER= | 0.006784 |
| Phi= | 0.950000 | Z2= | 60.000000 | CIEXP= | 1.000000 |
| R= | 0.006666 | Z3= | 72.000000 | BYEAR= | 1979 |
| DF= | 1.000000 | Z4= | 60.000000 | Z5= | 0.0 |
| | | | | Z6= | 0.0 |

CALCULATED VALUES

AG

SUM TO 1.1.2.6

9, MILLIONS

$$CD = CDCER \times (1 \times DF) \times (CDEXP) \times CF$$

0.0

$$CLRM = CICER \times (M) \times (CIEXP) \times CF \times TF$$

42.398

$$ORM = T / M$$

1.000

$$E = 1.0 + \text{LOG}(PHI) / \text{LOG}(2.0)$$

0.926

$$CTFU = (CLRM / E) \times (ORM \times (Z1 + 0.5) \times (E) - 0.5 \times (E))$$

42.551

$$CTB = ((CLRM / E) \times (ORM \times (Z3 + 0.5) \times (E) - 0.5 \times (E)))$$

1 / Z3

33.245

$$CIPS = CTB \times Z4 / Z2$$

33.245

$$CRC1 = CTB \times R$$

0.222

$$\text{PRE-IOC } CRC1 = CRC1 \times Z6$$

0.0

$$\text{POST-IOC } CRC1 = CRC1 \times (1.0 - Z6)$$

0.222

$$CUEM = UEM \text{ OR } CTB \times Z5 / Z2 / ENVR$$

0.0

COMMENTS

1977 DATA ENTERED FOR CDCER, CICER, AND UEM WERE

0.0

0.005798

0.0

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.2.6.2 GANTRY CRANE

INPUT PARAMETERS

INPUT COEFFICIENTS

| | | | | | |
|------|------------|------|-----------|--------|----------|
| T= | 40000.0000 | TF= | 1.000000 | CDCER= | 0.273780 |
| M= | 40000.0000 | DEM= | 0.0 | CDEXP= | 3.653000 |
| CF= | 1.100000 | Z1= | 1.000000 | CICER= | 0.000006 |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 1.000000 |
| R= | 0.0 | Z3= | 60.000000 | BYEAR= | 1979 |
| DF= | 0.200000 | Z4= | 60.000000 | 25= | 0.0 |
| | | | | 26= | 0.0 |

CALCULATED VALUES

AG

SUM TO 1.1.2.6

\$, MILLIONS

CU=CDCER X (T X DF)X(CDEXP) X CF 106.540

CLRM=CICER X (M)X(CIEXP) X CF X TF 0.257

ORM = T / M 1.000

E = 1.0 + LOG(PHI) / LOG(2.0) 1.000

CTFU=(CLRM / E)X(ORM X Z1+0.5)X(E) -0.5X(E) 0.257

CTB =((CLRM/E)X(ORM X Z3 + 0.5)X(E) -0.5X(E)) / Z3 0.257

CIPS=CTB*Z4/Z2 0.257

CRC1 =CTB X R 0.0

PRE-IOC CRC1 =CRC1 X Z6 0.0

POST-IOC CRC1 =CRC1 X (1.0-Z6) 0.0

CORR =DEM OR CIB*Z5/Z2/ENR 0.0

COMMENTS

1977 DATA ENTERED FOR CDCER, CICER, AND DEM WERE 0.234000 0.000005 0.0

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.2.6.3 UN-CRANE CONTROL CENTER

INPUT PARAMETERS

INPUT COEFFICIENTS

| | | | | | |
|------|------------|------|-----------|--------|----------|
| T= | 50000.0000 | TF= | 1.000000 | CDCER= | 0.014545 |
| M= | 50000.0000 | UEM= | 0.0 | CDEXP= | 1.000000 |
| CF= | 1.000000 | Z1= | 0.100000 | CICER= | 0.006784 |
| PHI= | 0.450000 | Z2= | 60.000000 | CIEXP= | 1.000000 |
| R= | 0.000555 | Z3= | 7.000000 | BYEAR= | 1979 |
| DF= | 1.000000 | Z4= | 6.000000 | Z5= | 0.0 |
| | | | | Z6= | 0.0 |

CALCULATED VALUES

AG

SUM TO 1.1.2.6

\$, MILLIONS

$$CD = CDCER \times (1 \times DF) \times (CDEXP) \times CF$$

727.272

$$CLRM = CICER \times (M) \times (CIEXP) \times CF \times TF$$

339.183

$$ORM = 1 / M$$

1.000

$$E = 1.0 + \text{LOG}(PHI) / \text{LOG}(2.0)$$

0.926

$$CTFU = (CLRM / E) \times ((ORM \times Z1 + 0.5) \times (E) - 0.5 \times (E))$$

35.456

$$CTB = ((CLRM / E) \times ((ORM \times Z3 + 0.5) \times (E) - 0.5 \times (E)))$$

1 / Z3

310.549

$$CIPS = CTB \times Z4 / Z2$$

31.055

$$CRC1 = CTB \times R$$

0.172

$$\text{PRE-IOC } CRC1 = CRC1 \times Z6$$

0.0

$$\text{POST-IOC } CRC1 = CRC1 \times (1.0 - Z6)$$

0.172

$$COEM = OGM \text{ OR } CTF \times Z5 / Z2 / ENVR$$

0.0

COMMENTS

1977 DATA ENTERED FOR CDCER, CICER, AND UEM WERE 0.012432 0.005798 0.0
COMMON USE EQUIPMENT. TRANSPORTABLE ITEMS AVAILABLE TO SERVICE OTHER
SATELLITES

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.2.6.4 TRACKS & ACCESS WAYS

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|---|------------|------|----------------|--------------------|----------|-------|-----|
| T= | 12000.0000 | TF= | 1.000000 | CDCER= | 0.0 | | |
| M= | 12000.0000 | UEM= | 0.0 | CDEXP= | 0.0 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.000058 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.0 | Z3= | 60.000000 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 60.000000 | Z5= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | AG | SUM TO 1.1.2.6 | \$, MILLIONS | | | |
| CD=CDCER X (T X DF)X(CDEXP) X CF | | | | 0.0 | | | |
| CLRM=CICER X (M)X(CIEXP) X CF X TF | | | | 0.702 | | | |
| EORM =T / M | | | | 1.000 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 1.000 | | | |
| CTFU=(CLRM / E)X(EORM X Z1+0.5)X(E) -0.5X(E) | | | | 0.702 | | | |
| CTB =((CLRM/E)X(EORM X Z3 + 0.5)X(E) -0.5X(E)) | | | | 1 / Z3 | | 0.702 | |
| CIPS=CTB*Z4/Z2 | | | | 0.702 | | | |
| CRC1 =CTB X R | | | | 0.0 | | | |
| PRE-IOC CRC1 =CRC1 X Z6 | | | | 0.0 | | | |
| POST-IOC CRC1 =CRC1 X (1.0-Z6) | | | | 0.0 | | | |
| COEM =OEM OR CTR*Z5/Z2/ENYR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND UEM WERE 0.0 0.000050 0.0 | | | | | | | |

1.1.3 INFORMATION MANAGEMENT AND CONTROL

This element includes those components that process information on board the satellite. This includes sensing, signal conditioning, formatting, computations, and signal routing.

The information management and control subsystem (IMCS) includes inter-connecting elements between and within all satellites and ground-based operational subsystems. The IMCS also provides operational control of both the satellite and ground systems as well as providing for subsystem processing support on all but very special functions.

The satellite IMCS consists of on-board processing equipment central processing units (CPU) and memories, inter- and intra-subsystem data network (data buses), man-machine interfaces (display/control), and inter-system communication links, including RF. Items not included are those specifically provided for the control and transfer of primary power, and all elements related to system security, safety, or any other operation necessary to the continuing operation of the SPS.

Because of the early stage of program analysis, only those requirements imposed upon the IMCS by a limited number of satellite operations have been identified. These requirements generally are limited to those associated with immediate operations of an active satellite. Auxiliary functions such as ground/space communications, display/control, safety, security, etc., will be added when data become available.

The usage and application of IMCS items are identified in Table 1.1-7, and illustrate the association within subsystem functions.

Table 1.1-7. Usage/Application Matrix per Satellite

| | INSTRUMENTATION | | DATA ACQUISITION | | DATA PROCESSING | | | CONTROL | | |
|-------------------------|-----------------|------------------------|------------------|-------------------|------------------------|-------------|-----------------------|------------------------|------------------------|------------|
| ELEMENT DESCRIPTION | SENSORS | SIGNAL CONDITIONING | SOFTWARE | SIGNAL ROUTING | SOFTWARE FORMATTING | COMPUTATION | DISPLAY GENERATION | DISPLAYS & CONTROLS | SIGNAL CONDITIONING | WBS NO. |
| MASTER CONTROL COMPUTER | | | | | X | X | X | | | 1.1.3.1 |
| DISPLAYS CONTROL | | | | | X | X | X | X | | 1.1.3.2 |
| SUPERVISORY COMPUTER | | | | | X | X | X | | | 1.1.3.3 |
| REMOTE COMPUTER | | | | | X | X | X | | | 1.1.3.4 |
| BUS CONTROL UNIT | | | X | X | X | X | X | | | 1.1.3.5 |
| MICROPROCESSORS | | | | | X | X | X | | | 1.1.3.6 |
| REMOTE ACQ. & CONTROL | | | X | X | X | X | X | | X | 1.1.3.7 |
| SUB-MULTIPLEXER | | | X | X | X | X | X | | | 1.1.3.8 |
| INSTRUMENTATION | X | X | | | | | | | | 1.1.3.9 |
| FIBER OPTICS | | | | X | | | | | | 1.1.3.10 |
| CABLES & HARNESSES | X | X | X | X | X | X | X | X | X | 1.1.3.11 |

These items have been separated into general hardware groups for costing purposes.

COMPUTERS

Historical cost data were obtained for computers from the Redstar Data Base system and are listed below:

- Gemini-3
- Minuteman
- Skylab
- Viking Lander
- MOL
- HEAO

A 50% integration factor was included in the DDT&E CERs to allow for subsystem-level costs.

Range of Data:

DDT&E and ICI: 1.8 to 75.7 kg

ELECTRONIC COMPONENTS

Electronic components include submultiplexers, remote acquisition units, microprocessors, bus control units, and instrumentation.

Development of an electronic component's CER was based on selected components of the ATS-F and OSO-8 spacecraft; 19 electronic components are listed below:

| ATS-F | OSO-8 |
|-------------------------------|-----------------------------|
| Auxiliary digital sun sensors | Solar power supply |
| Monopulse unit | Power supply |
| Wideband data unit | Control decoder/demodulator |
| C-band data unit | Remote decoder |
| S/L-band transmitter | PCM decoder |
| VHF receiver | Format generator |
| Command decoder | Wheel clock |
| Data acquis. and control unit | Sail clock |
| Data switching unit | S-band transmitter |
| | VHF transmitter |

Range of Data:

DDT&E and ICI: 1.1 to 19.6 kg

DATA BUS

This element consists of both copper wire and fiber optics. Historical cost data were obtained from the Redstar Data Base to produce a data bus DDT&E CER. Commercial prices were used for the data bus ICI CER.

Production cost information obtained from private industry for "off-the-shelf" fiber optics and copper wire are listed below.

Fiber Optics

| <u>Manufacturer</u> | <u>Type</u> | <u>Characteristics</u> | <u>Cost per Meter</u> |
|--|-------------|----------------------------|-----------------------|
| ITT Electro-Optical Products Division | GG-02 | Single fiber, 50 m dia. | (1-10 km) \$3.25 |
| | GS-02 | Single fiber, 50 m dia. | \$2.50 |
| Valtec Fiberoptics Division | MG-05 | Single fiber, 65 m dia. | \$2.50 |
| Galileo Electro- Optics Corp. | - | Single fiber, 88 m dia. | \$1.58 |
| Average cost per meter | | | \$2.40 |

One industry spokesman estimates that the cost of optical fibers would likely decrease to 40% by 1980. This study assumes a \$2.40 per meter average price reduced by 40% to \$1.44 per meter.

Copper Wire

| <u>Manufacturer</u> | <u>Characteristics</u> | <u>Cost per Meter</u> |
|--------------------------------------|---------------------------------------|-----------------------|
| Dearborn Wire & Cable | 22-gauge, stranded silver plate | \$ 0.807 |
| Standard Wire & Cable | 22-gauge, stranded silver plate | \$ 0.705 |
| Karen, Inc. | 22-gauge, 2-conductor silver plate | \$ 0.807 |
| Mil-Spec Wire & Cable Corporation | 22-gauge, 19-30 stranded | \$ 0.610 |
| Average cost per meter | | \$ 0.732 |

Instrumentation input parameters' T&M are in kilograms.

Cost estimates for the items of Table 1.1-7 are presented in Tables 1.1.3.1 through 1.1.3.11, inclusive.

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.3.1 MASTER CONTROL COMPUTER

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|---|------------|------|--------------|--------------------|----------|-----|-----|
| T= | 1000.00000 | TF= | 0.900000 | CDCER= | 0.740610 | | |
| M= | 500.000000 | UGM= | 0.0 | CDEXP= | 0.521000 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.201240 | | |
| PHI= | 0.800000 | Z2= | 60.000000 | CIEXP= | 0.535000 | | |
| R= | 0.003333 | Z3= | 66.000000 | BYEAR= | 1979 | | |
| DF= | 0.500000 | Z4= | 60.000000 | 25= | 0.0 | 26= | 0.0 |
| CALCULATED VALUES | | KG | SUM TO 1.1.3 | \$, MILLIONS | | | |
| CD=CDCER X (T X DF)XX(CDEXP) X CF | | | | 18.869 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 5.034 | | | |
| ARM = T / M | | | | 2.000 | | | |
| E = 1.0 + LOG(PHI) / LOG(2.0) | | | | 0.678 | | | |
| CTFU=(CLRM / E)X((ARM X Z1+0.5)XX(E) -0.5XX(E)) | | | | 9.179 | | | |
| CTB = ((CLRM/E)X((ARM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | 1 / Z3 | 3.021 | | | |
| CIPS=CTB*7.4/Z2 | | | | 3.021 | | | |
| CRCI = CTB X R | | | | 0.010 | | | |
| PRE-IGC CRCI = CRCI X Z6 | | | | 0.0 | | | |
| POST-IGC CRCI = CRCI X (1.0-Z6) | | | | 0.010 | | | |
| COEM = OEM OR CTR*25/Z2/ENVR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CULER, CICER, AND UGM WERE | | | | 0.633000 | 0.172000 | 0.0 | |
| REFERENCE PRECURSOR REQUIREMENTS 1.1.9.1.40 | | | | | | | |

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ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.3.2 DISPLAYS & CONTROLS

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|------------|--------------|-----------|--------------------|----------|-----|-----|
| T= | 200.000000 | TF= | 0.900000 | CDCER= | 0.119340 | | |
| M= | 200.000000 | DEM= | 0.0 | CDEXP= | 0.879000 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.080730 | | |
| PHI= | 0.800000 | Z2= | 60.000000 | CIEXP= | 0.557000 | | |
| R= | 0.003333 | Z3= | 66.000000 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 60.000000 | Z5= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | SUM TO 1.1.3 | | \$,MILLIONS | | | |
| CD=CDCER X (T X DF)XX(CDEXP) X CF | | | | 12.572 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 1.390 | | | |
| WRM =T / M | | | | 1.000 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 0.678 | | | |
| CTFU=(CLRM / E)X((WRM X Z1+.5)XX(E) -0.5XX(E)) | | | | 1.417 | | | |
| CTB =(CLRM/E)X((WRM X Z3 + 0.5)XX(E) -0.5XX(E)) | |) / Z3 | | 0.515 | | | |
| CIPS=CTB*Z4/Z2 | | | | 0.515 | | | |
| CRC1 =CTB X R | | | | 0.002 | | | |
| PRE-IOC CRC1 =CRC1 X Z6 | | | | 0.0 | | | |
| POST-IOC CRC1 =CRC1 X (1.0-Z6) | | | | 0.002 | | | |
| COEM =DEM OR CTR*Z5/Z2/ENYR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND DEM WERE | | | | 0.102000 | 0.069000 | 0.0 | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.3.3 SUPERVISORY COMPUTER

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|-----------|------|--------------|--------------------|----------|-------|-----|
| T= | 84.000000 | TF= | 0.700000 | CDCER= | 0.740610 | | |
| M= | 14.000000 | UGM= | 0.0 | CDEXP= | 0.521000 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.201240 | | |
| PHI= | 0.850000 | Z2= | 60.000000 | CIEXP= | 0.535000 | | |
| R= | 0.003333 | Z3= | 60.000000 | BYEAR= | 1979 | | |
| DF= | 0.200000 | Z4= | 60.000000 | 25= | 0.0 | 26= | 0.0 |
| CALCULATED VALUES | | K6 | SUM TO 1.1.3 | \$,MILLIONS | | | |
| CU=CDCER X (T X DF)XX(CDEXP) X CF | | | | 3.221 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 0.578 | | | |
| ORM =T / M | | | | 6.000 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 0.766 | | | |
| CIFU=(CLRM / E)X((ORM X Z1+0.5)XX(E) -0.5XX(E)) | | | | 2.721 | | | |
| CTB =((CLRM/E)X((ORM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | |) / Z3 | | 1.109 | |
| LIPS=CTB*24/22 | | | | 1.109 | | | |
| CRC1 =CTB X R | | | | 0.004 | | | |
| PRE-IUC CRC1 =CRC1 X Z6 | | | | 0.0 | | | |
| POST-IUC CRC1 =CRC1 X (1.0-Z6) | | | | 0.004 | | | |
| COGM =OGM OR CTB*25/22/ENVR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND UGM WERE | | | | 0.633000 | 0.172000 | 0.0 | |
| 6 REQUIRED FOR RCI | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.3.4 REMOTE COMPUTER

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|---|------------|------|--------------|--------------------|----------|-------|-----|
| T= | 518.000000 | TF= | 0.400000 | CD CER= | 0.740610 | | |
| M= | 14.000000 | CEM= | 0.0 | CE EXP= | 0.521000 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.201240 | | |
| PHI= | 0.850000 | Z2= | 60.000000 | CI EXP= | 0.535000 | | |
| R= | 0.003333 | Z3= | 60.000000 | BYEAR= | 1979 | | |
| DF= | 0.030000 | Z4= | 60.000000 | Z5= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | KB | SUM TO 1.1.3 | \$, MILLIONS | | | |
| CD=CD CER X (T X DF)XX(CE EXP) X CF | | | | 3.093 | | | |
| CLRM=CICER X (M)XX(CI EXP) X CF X TF | | | | 0.330 | | | |
| EORM =T / M | | | | 37.000 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 0.766 | | | |
| CTFU=(CLRM / E)X(EORM X (1+.5)XX(E) -0.5XX(E)) | | | | 6.664 | | | |
| CTB =((CLRM/E)X(EORM X (Z3 + 0.5)XX(E) -0.5XX(E)) | | | |) / Z3 | | 2.560 | |
| CIPS=CTB*24/22 | | | | 2.560 | | | |
| CRC1 =CTB X R | | | | 0.009 | | | |
| PRE-IOC CRC1 =CRC1 X Z6 | | | | 0.0 | | | |
| POST-IOC CRC1 =CRC1 X (1.0-Z6) | | | | 0.009 | | | |
| CEM =CEM OR CIP*25/22/ENR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CD CER, CICER, AND CEM WERE | | | | 0.633000 | 0.172000 | 0.0 | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.3.5 BUS CONTROL UNIT

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|------------|------|--------------|--------------------|----------|-------|-----|
| T= | 4110.00000 | TF= | 0.076000 | CDCER= | 0.119340 | | |
| M= | 5.000000 | UEM= | 0.0 | CDEXP= | 0.879000 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.080730 | | |
| PHI= | 0.950000 | Z2= | 60.000000 | CIEXP= | 0.557000 | | |
| R= | 0.003330 | Z3= | 66.000000 | BYEAR= | 1979 | | |
| DF= | 0.012000 | Z4= | 60.000000 | Z5= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | K6 | SUM TO 1.1.3 | \$,MILLIONS | | | |
| CU=CDCER X (T X DF)XX(CDEXP) X CF | | | | 3.672 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 0.015 | | | |
| WRM =T / M | | | | 822.000 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 0.926 | | | |
| CTFU=(CLRM / E)X((WRM X Z1+.5)XX(E) -0.5XX(E)) | | | | 8.119 | | | |
| CTB =((CLRM/E)X((WRM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | |) / Z3 | | 5.958 | |
| CIPS=CTB*Z4/Z2 | | | | 5.958 | | | |
| CRC1 =CTB X R | | | | 0.020 | | | |
| PRE-IOC CRC1 =CRC1 X Z6 | | | | 0.0 | | | |
| POST-IOC CRC1 =CRC1 X (1.0-Z6) | | | | 0.020 | | | |
| UEM =UEM OR CTH*Z5/Z2/ENR | | | | 0.0 | | | |

COMMENTS

1977 DATA ENTERED FOR CDCER, CICER, AND UEM WERE 0.102000 0.069000 0.0
822 UNITS REQUIRED. REFR PRECURSOR REQUIREMENTS 1.1.9.1.41

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.3.6 MICROPROCESSORS

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|------------|------|--------------|--------------------|----------|-----|-----|
| T= | 3885.00000 | TF= | 0.078000 | CDCER= | 0.119340 | | |
| M= | 5.000000 | UEM= | 0.0 | CDEXP= | 0.879000 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.080730 | | |
| PHI= | 0.950000 | Z2= | 60.000000 | CIEXP= | 0.557000 | | |
| R= | 0.003333 | Z3= | 66.000000 | RYEAR= | 1979 | | |
| DF= | 0.013000 | Z4= | 60.000000 | Z5= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | KB | SUM TO 1.1.3 | \$, MILLIONS | | | |
| CD=CDCER X (1 X DF)XX(CDEXP) X CF | | | | 3.750 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 0.015 | | | |
| ORM =T / M | | | | 777.000 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 0.926 | | | |
| CTFU=(CLRM / E)X(ORM X Z1+.5)XX(E) -0.5XX(E) | | | | 7.910 | | | |
| CTB =((CLRM/E)X(ORM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | 1 / Z3 | 5.804 | | | |
| CIPS=CTB#Z4/Z2 | | | | 5.804 | | | |
| CRL1 =CTB X R | | | | 0.019 | | | |
| PRE-IOC CRL1 =CRL1 X Z6 | | | | 0.0 | | | |
| POST-IOC CRL1 =CRL1 X (1.0-Z6) | | | | 0.019 | | | |
| LOEM =UEM OR CTB#Z5/Z2/ENYR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND UEM WERE | | | | 0.102000 | 0.069000 | 0.0 | |
| 777 MICRO-PROCESSORS REF. PRECURSOR REQUIREMENTS 1.1.9.1.4.2 | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.3.7 REMOTE ACQUISITION & CONTROL

INPUT PARAMETERS

INPUT COEFFICIENTS

| | | | | | |
|------|------------|------|-----------|--------|----------|
| T= | 4925.00000 | TF= | 0.069000 | CDCER= | 0.119340 |
| M= | 5.000000 | OEM= | 0.0 | CDEXP= | 0.879000 |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.080730 |
| PHI= | 0.950000 | Z2= | 60.000000 | CIEXP= | 0.557000 |
| R= | 0.003333 | Z3= | 66.000000 | BYEAR= | 1979 |
| DF= | 0.010000 | Z4= | 60.000000 | Z5= | 0.0 |
| | | | | Z6= | 0.0 |

CALCULATED VALUES

KG

SUM TO 1.1.3

\$, MILLIONS

CD=CDCER X (T X DF)XX(CDEXP) X CF

3.668

CLRM=CICER X (M)XX(CIEXP) X CF X TF

0.014

#RM = T / M

985.000

E = 1.0 + LOG(PHI) / LOG(2.0)

0.926

CTFU=(CLRM / E)X((#RM X Z1+0.5)XX(E) -0.5XX(E))

8.716

CTB =((CLRM/E)X((#RM X Z3 + 0.5)XX(E) -0.5XX(E))

) / Z3

6.395

CIPS=CTB*Z4/Z2

6.395

CRC1 =CTB X R

0.021

PRE-IOC CRC1 =CRC1 X Z6

0.0

POST-IOC CRC1 =CRC1 X (1.0-Z6)

0.021

COEM =OEM OR CTB*Z5/Z2/ENYR

0.0

COMMENTS

1977 DATA ENTERED FOR CDCER, CICER, AND OEM WERE
REFR PRELUSOR REQUIREMENT 1.1.4.1.43

0.102000

0.069000

0.0

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.3.8 SUBMULTIPLEXORS

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|------------------|------------|------|-----------|--------------------|----------|-----|-----|
| T= | 93000.0000 | TF= | 0.022000 | CDCER= | 0.119340 | | |
| M= | 3.000000 | OEM= | 0.0 | CDEXP= | 0.879000 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.080730 | | |
| PHI= | 0.960000 | Z2= | 60.000000 | CIEXP= | 0.557000 | | |
| R= | 0.003333 | Z3= | 66.000000 | BYEAR= | 1979 | | |
| DF= | 0.000320 | Z4= | 60.000000 | Z5= | 0.0 | Z6= | 0.0 |

CALCULATED VALUES KG SUM TO 1.1.3 \$, MILLIONS

CD=CDCER X (T X DF)XX(CDEXP) X CF 2.356

CLRM=CICER X (M)XX(CIEXP) X CF X TF 0.003

~~0.130~~ $\theta RM = T / M$ 31000.000

$E = 1.0 + \text{LOG}(PHI) / \text{LOG}(2.0)$ 0.971

CTFU=(CLRM / E)X(1+RM X Z1+0.5)XX(E) -0.5XX(E)) 77.359

CIB =(1+CLRM/E)X(1+RM X Z3 + 0.5)XX(E) -0.5XX(E)) 1 / Z3 68.467

CIPS=CTB*Z4/Z2 68.467

CRC1 =CTB X R 0.228

PRE-10C CRC1 =CRC1 X Z6 0.0

POST-10C CRC1 =CRC1 X (1.0-Z6) 0.228

CUEM =OEM OR CTB*Z5/Z2/ENYR 0.0

COMMENTS

1977 DATA ENTERED FOR CDCER, CICER, AND OEM WERE 0.102000 0.069000 0.0
REFR PRECURSOR REQUIREMENT 1.1.9.1.44

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.3.4 INSTRUMENTATION

INPUT PARAMETERS

INPUT COEFFICIENTS

| | | | | | |
|------|------------|------|-----------|--------|----------|
| T= | 289000.000 | TF= | 1.000000 | CDCER= | 0.000117 |
| M= | 0.074100 | UEM= | 0.0 | CDEXP= | 1.000000 |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.000468 |
| PHI= | 0.960000 | Z2= | 60.000000 | CIEXP= | 1.000000 |
| R= | 0.003333 | Z3= | 66.000000 | BYEAR= | 1979 |
| DF= | 1.000000 | Z4= | 60.000000 | Z5= | 0.0 |
| | | | | Z6= | 0.0 |

CALCULATED VALUES

KG

SUM TO 1.1.3

\$, MILLIONS

$$CD = CDCER \times (T \times DF) \times (CDEXP) \times CF$$

33.813

$$CLRM = CICER \times (M) \times (CIEXP) \times CF \times TF$$

0.000

$$ARM = T / M$$

3900134.00

$$E = 1.0 + \text{LUG}(PHI) / \text{LOG}(2.0)$$

0.971

$$CTFU = (CLRM / E) \times ((ARM \times Z1 + 0.5) \times (E) - 0.5 \times (E))$$

89.513

$$CTB = ((CLRM / E) \times ((ARM \times Z3 + 0.5) \times (E) - 0.5 \times (E)))$$

1 / 23

79.222

$$CIPS = CTB \times Z4 / Z2$$

79.222

$$CRC1 = CTB \times R$$

0.264

$$\text{PRE-IUC } CRC1 = CRC1 \times Z6$$

0.0

$$\text{POST-IUC } CRC1 = CRC1 \times (1.0 - Z6)$$

0.264

$$CUEM = OEM \text{ OR } CTB \times Z5 / Z2 / \text{ENYR}$$

0.0

COMMENTS

1977 DATA ENTERED FOR CDCER, CICER, AND OEM WERE 0.000100 0.000400 0.0
M=APPROX MASS PFK SENSOR. KFKH PRECURSOR REQUIREMENTS 1.1.9.1.45

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ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.3.10 OPTICAL FIBER

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|-----------|------|--------------|--------------------|----------|-------|-----|
| T= | 62.000000 | TF= | 1.000000 | CDCER= | 0.277290 | | |
| M= | 62.000000 | UEM= | 0.0 | COEXP= | 0.297000 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.011956 | | |
| PHI= | 0.980000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.003333 | Z3= | 66.000000 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 60.000000 | Z5= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | K6 | SUM TO 1.1.3 | \$ MILLIONS | | | |
| CD=CDCER X (T X DF)X(COEXP) X CF | | | | 0.945 | | | |
| CLRM=CICER X (M)X(CIEXP) X CF X TF | | | | 0.741 | | | |
| EORM =T / M | | | | 1.000 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 0.971 | | | |
| CTFU=(CLRM / E)X(EORM X Z1+0.5)X(E) -0.5X(E) | | | | 0.742 | | | |
| CTB =((CLRM/E)X(EORM X Z3 + 0.5)X(E) -0.5X(E)) | | | | 1 / Z3 | | 0.675 | |
| CIPS=CTB*Z4/Z2 | | | | 0.675 | | | |
| CRC1 =CTB X R | | | | 0.002 | | | |
| PRE-10C CRC1 =CRC1 X Z6 | | | | 0.0 | | | |
| POST-10C CRC1 =CRC1 X (1.0-Z6) | | | | 0.002 | | | |
| UEM =UEM OR CTB*Z5/Z2/ENVR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND UEM WERE | | | | 0.237000 | 0.010219 | 0.0 | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.3.11 CABLES/HARNESS

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|---|------------|------|--------------|--------------------|----------|-----|-----|
| T= | 293000.000 | TF= | 1.000000 | CDCER= | 0.277290 | | |
| M= | 377.000000 | UEM= | 0.0 | CDEXP= | 0.297000 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.000070 | | |
| PHI= | 0.900000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.003333 | Z3= | 66.000000 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 60.000000 | Z5= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | 16 | SUM TO 1.1.3 | \$, MILLIONS | | | |
| CD=CDCER X (1 X UH) X (CDEXP) X CF | | | | 11.657 | | | |
| CLRM=CICER X (M) X (CIEXP) X CF X TF | | | | 0.026 | | | |
| UHM = T / M | | | | 777.188 | | | |
| E = 1.0 + LOG(PHI) / LOG(2.0) | | | | 0.971 | | | |
| CTBU=(CLRM / E) X (UHM X Z1 + 0.5) X (E - 0.5 X (E)) | | | | 17.447 | | | |
| CTB = ((CLRM/E) X (UHM X Z3 + 0.5) X (E - 0.5 X (E))) | | | | 1 / Z3 | 15.444 | | |
| CIPS=CTB X Z4 / Z2 | | | | 15.444 | | | |
| CRC1 = CTB X R | | | | 0.051 | | | |
| PRE-IOC CRC1 = CRC1 X Z6 | | | | 0.0 | | | |
| POST-IOC CRC1 = CRC1 X (1.0 - Z6) | | | | 0.051 | | | |
| COEM = UEM OR CTB X Z5 / Z2 / ENVR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND UEM WERE | | | | 0.237000 | 0.000060 | 0.0 | |
| 777 MECHANICAL MODULES | | | | | | | |

1.1.4 ATTITUDE CONTROL AND STATIONKEEPING

This element includes components required to orient and maintain satellite position and attitude in geosynchronous orbit as shown in Figure 1.1-8. Major items include the attitude reference determination system with sensors, processors and gyros, reaction control system components and thrusters, plus power processing equipment and propellants.

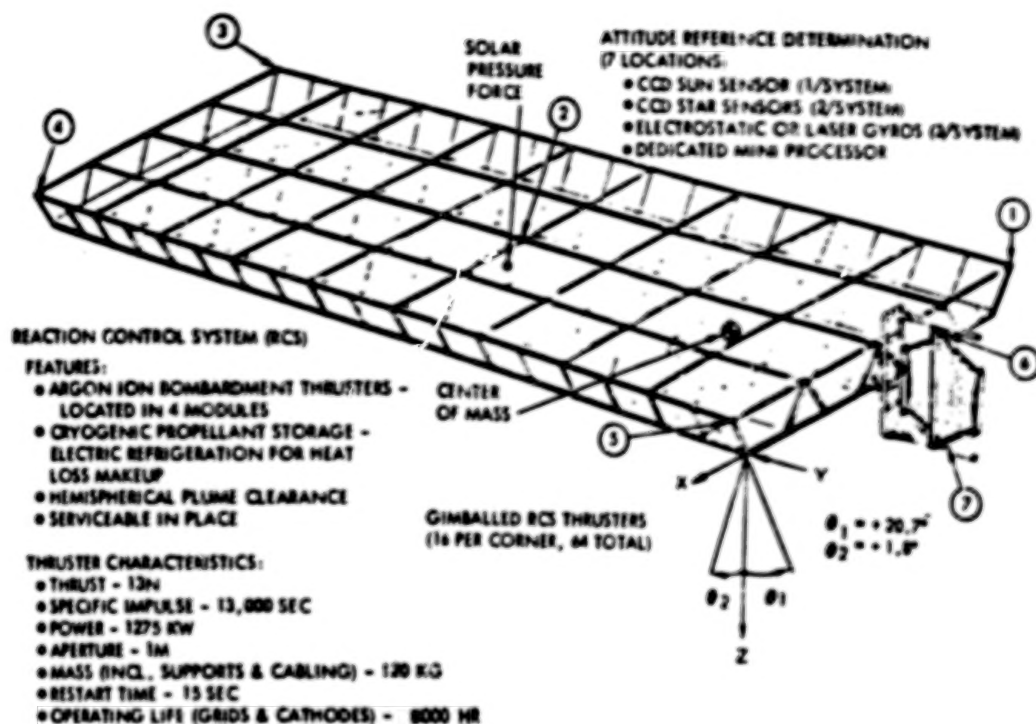


Figure 1.1-8. ACSS Equipment Locations

The baseline ACSS features an argon-ion bombardment thruster RCS whose characteristics are:

- Thrusters located in four modules at each corner of the satellite
- Each module has 16 thrusters
- Cryogenic propellant storage/electric refrigeration with heat loss makeup
- Hemispherical plume characteristics
- Serviceable in place

The system operates on an average of 36 thrusters. A total of 64 thrusters is included to provide the required redundancy. The redundancy was based on an annual maintenance/servicing interval, 5000-hour thruster grid lifetime, and five-year thruster MTBF. Sixteen thrusters are located on the lower portion of each corner of the spacecraft. Each thruster is gimballed individually to facilitate thruster servicing, to permit operation of adjacent thrusters during

servicing, and to provide redundancy. The thrusters nominally provide a force vector approximately in the direction of the sun to counter solar pressure force (stationkeeping) which is the dominant thruster requirement. Thrusters are gimballed through small angles (as illustrated) and differentially throttled to provide remaining forces and torques for attitude control and stationkeeping.

Sensors that make up the attitude reference determination system include:

- CCD sun sensor (one/system)
- CCD star sensors (two/system)
- Electrostatic or laser gyros (3/system)
- Dedicated mini-processor

The attitude reference determination system features charged coupled device (CCE), star and sun sensors as well as electrostatic or laser gyros and dedicated microprocessors. Seven attitude reference determination units are located at various locations on the satellite in order to sense thermal and dynamic body bending, and to desensitize the system to these disturbances. The control algorithms will feature statistical estimates for determining principal axis orientation, body bending state observers or estimators, and a quasi-linear propulsion thrust command policy to provide precise control and minimize structural bending excitation.

Mass properties of the ACSS are presented in Table 1.1-8. This summary includes the mass of individual elements with propellant weight on an annual basis per satellite.

Table 1.1-8. ACSS Mass Summary

| <u>Reference WBS No.</u> | <u>Item</u> | <u>Mass/ kg</u> |
|------------------------------|---|---------------------|
| 1.1.4.1.1 | Attitude Reference Determination Systems (7) | 1,000 |
| 1.1.4.1.1 | Thrusters—64 @ 120 kg/thruster | 7,335 |
| 1.1.4.1.4 | Thruster gimbals and mounting | 2,000 |
| 1.1.4.1.2 | Condustrors/insulation | 2,000 |
| 1.1.4.1.1 | Tanks, lines, refrigeration | 8,500 |
| 1.1.4.1.3 | Power processing equipment | 2,000 |
| Total (dry) | | 22,835 |
| 1.1.4.2 | Argon propellant—annual requirement/satellite | 85,390 |

Historical cost data were obtained from NASA's Redstar Data Base; however, it is limited relative to electrical propulsion. Consequently, study data were utilized where necessary. Ion bombardment thrusters are argon propellants with a low thrust but significantly higher specific impulse, thus reducing propellant resupply cost.

Development of the propulsion subsystem CERS was based on spacecraft programs listed below:

- SEPS (Boeing) Study
- SEPS (Rockwell) Study
- SERT-II
- ATS-F (Ion Experiment)
- Rockwell SPS Study
- SERT-C Study

Range of Data:

DDT&E and ICI: 18.0 to 107,500 kg

Cost estimates are identified in Tables 1.1.4.1.1, 1.1.4.1.2, 1.1.4.1.3, 1.1.4.1.4, and 1.1.4.2.

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ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.4.1.1 ACS THRUSTER COMPONENTS

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|------------|------|----------------|--------------------|----------|--------|-----|
| T= | 16835.0000 | TF= | 0.300000 | CDCER= | 1.312739 | | |
| M= | 140.000000 | UEM= | 0.0 | CDEXP= | 0.140000 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.066690 | | |
| PHI= | 0.960000 | Z2= | 60.000000 | CIEXP= | 0.729000 | | |
| R= | 0.003333 | Z3= | 66.000000 | RYEAR= | 1979 | | |
| DF= | 0.300000 | Z4= | 60.000000 | Z5= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | KG | SUM TO 1.1.4.1 | \$, MILLIONS | | | |
| CD=CDCER X (T X DF)XX(CDEXP) X CF | | | | 6.635 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 0.734 | | | |
| WRM =T / M | | | | 120.250 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 0.971 | | | |
| CTFU=(CLRM / E)X((WRM X Z1+.5)XX(E) -0.5XX(E)) | | | | 79.004 | | | |
| CTB =((CLRM/E)X((WRM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | |) / Z3 | | 69.979 | |
| CIPS=CTB*Z4/Z2 | | | | 69.979 | | | |
| CRC1 =CTB X R | | | | 0.233 | | | |
| PRE-IDC CRC1 =CRC1 X Z6 | | | | 0.0 | | | |
| POST-IDC CRC1 =CRC1 X (1.0-Z6) | | | | 0.233 | | | |
| CUEM =UEM OR CTB*Z5/Z2/ENYR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND UEM WERE 1.122000 0.057000 0.0 | | | | | | | |
| INCLUDES 64 THRUSTERS, TANKS, PROPELLANT LINES, AND ATTITUDE REFR. | | | | | | | |
| SYSTEM | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.4.1.2 ACS - CONDUCTORS & INSULATION

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|---|------------|------|----------------|--------------------|----------|-----|-----|
| T= | 2000.00000 | TF= | 1.000000 | CDCER= | 0.184860 | | |
| M= | 500.000000 | UGM= | 0.0 | CDEXP= | 0.297000 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.000005 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.0 | Z3= | 60.000000 | BYEAR= | 1979 | | |
| DF= | 0.100000 | Z4= | 60.000000 | 25= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | KG | SUM TO 1.1.4.1 | \$,MILLIONS | | | |
| CD=CDCER X (1 X DF)XX(CDEXP) X CF | | | | 0.892 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 0.002 | | | |
| ORM =T / M | | | | 4.000 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 1.000 | | | |
| CTFU=(CLRM / E)X(ORM X Z1+.5)XX(E) -0.5XX(E)) | | | | 0.009 | | | |
| CTB =((CLRM/E)X((ORM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | | 1 / Z3 | 0.009 | | |
| CIPS=CTB*Z4/Z2 | | | | 0.009 | | | |
| CRCI =CTB X R | | | | 0.0 | | | |
| PRE-IOC CRCI =CRCI X Z6 | | | | 0.0 | | | |
| POST-IOC CRCI =CRCI X (1.0-Z6) | | | | 0.0 | | | |
| COEM =UGM OR CTB*Z5/Z2/ENYR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND UGM WERE ASSOCIATED WITH ACS THRUSTER COMPLEXES | | | | 0.158000 | 0.000004 | 0.0 | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.4.1.3 ACS - POWER PROCESSING EQUIPMENT

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|---|------------|------|----------------|--------------------|----------|-----|-----|
| T= | 2000.00000 | TF= | 1.000000 | CDCEI= | 0.184860 | | |
| M= | 500.000000 | UEM= | 0.0 | COEXP= | 0.297000 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.000468 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.0 | Z3= | 60.000000 | 9YEAR= | 1979 | | |
| DF= | 0.500000 | Z4= | 60.000000 | Z5= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | RG | SUM TO 1.1.4.1 | \$,MILLIONS | | | |
| CD=CDCEI X (1 X DF)XX(COEXP) X CF | | | | 1.438 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 0.234 | | | |
| URM =T / M | | | | 4.000 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 1.900 | | | |
| CTFU=(CLRM / E)X(URM X Z1+0.5)XX(E) -0.5XX(E) | | | | 0.936 | | | |
| CTB =((CLRM/E)X(URM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | |) / Z3 | | | |
| CIPS=CTB*Z4/Z2 | | | | 0.936 | | | |
| CRC1 =CTB X R | | | | 0.0 | | | |
| PRE-IDC CRC1 =CRC1 X Z6 | | | | 0.0 | | | |
| POST-IDC CRC1 =CRC1 X (1.0-Z6) | | | | 0.0 | | | |
| CUEM =UEM OR CTB*Z5/Z2/ENYR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1979 DATA ENTERED FOR CUCER,CICER, AND UEM WERE | | | | 0.184860 | 0.000468 | 0.0 | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.4.1.4 ALS - THRUSTER GIMBALS AND MOUNTING

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|------------|----------------|-----------|--------------------|----------|-----|-----|
| T= | 2000.00000 | TF= | 1.000000 | CDCER= | 0.182520 | | |
| M= | 500.000000 | UEM= | 0.0 | CDEXP= | 0.511000 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.000894 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 0.950000 | | |
| R= | 0.0 | Z3= | 60.000000 | BYEAR= | 1979 | | |
| DF= | 0.500000 | Z4= | 60.000000 | Z5= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | SUM TO 1.1.4.1 | | \$, MILLIONS | | | |
| C1=CDCER X (1 X DF)XX(CDEXP) X CF | | | | 6.227 | | | |
| CLRM=CICER X (M)XX(CIEXP) X LF X TF | | | | 0.328 | | | |
| E = T / M | | | | 4.000 | | | |
| E = 1.0 + LOG(PHI) / LOG(2.0) | | | | 1.000 | | | |
| CTFU=(CLRM / E)X(10RM X Z1+0.5)XX(E) -0.5XX(E) | | | | 1.310 | | | |
| CTB =(CLRM/E)X(10RM X Z3 + 0.5)XX(E) -0.5XX(E) | | 1 / Z3 | | 1.310 | | | |
| CIPS=CTB*24/22 | | | | 1.310 | | | |
| CRC1 =CTB X R | | | | 0.0 | | | |
| PRE-IOC CRC1 =CRC1 X Z6 | | | | 0.0 | | | |
| POST-IOC CRC1 =CRC1 X (1.0-Z6) | | | | 0.0 | | | |
| COEM =UEM OR CTB*25/22/ENVR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1979 DATA ENTERED FOR CDCER, CICER, AND UEM WERE | | | | 0.182520 | 0.000894 | 0.0 | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.4.2 ALSS PROPELLANT

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|---|----------|------|-----------|--------------------|-----|-------------|-----|
| T= | 1.000000 | TF= | 1.000000 | CDCEP= | 0.0 | | |
| M= | 1.000000 | UEM= | 0.094906 | CDEXP= | 0.0 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.0 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 0.0 | | |
| R= | 0.0 | Z3= | 60.000000 | BYEAR= | | 1979 | |
| DF= | 1.000000 | Z4= | 60.000000 | Z5= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | | | SUM TO 1.1.4 | | \$,MILLIONS | |
| CD=CDCEP X (1 X DF/AX(CDEXP) X CF | | | | | | 0.0 | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | | | 0.0 | |
| ORM =T / M | | | | | | 1.000 | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | | | 1.000 | |
| CIFU=(CLRM / E)X((ORM X Z1+.5)XX(E) -0.5XX(E)) | | | | | | 0.0 | |
| CTB =((CLRM/E)X((ORM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | |) / Z3 | | 0.0 | |
| CIPS=CTB*Z4/Z2 | | | | | | 0.0 | |
| CRC1 =CTB X R | | | | | | 0.0 | |
| PRE-IUC CRC1 =CRC1 X Z6 | | | | | | 0.0 | |
| POST-IUC LNC1 =CRC1 X (1.0-Z6) | | | | | | 0.0 | |
| COEM =UEM OR CTB*Z5/Z2/ENWR | | | | | | 0.100 | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCEP, CICER, AND UEM WERE | | | | 0.0 | 0.0 | 0.005390 | |
| OEM PROPELLANT (S1/AG-1977) = S1.17/AG AT 85390 KG/SA1/YR | | | | | | | |

1.1.5 COMMUNICATIONS

This element includes hardware to transmit and receive intelligence from among various SPS elements (satellite, construction and LEO base, transportation systems, ground receiving station). It includes communication of both data and voice between the SPS and the control center, as well as among various cargo and personnel vehicles. Excluded are intravehicular and intra-satellite communications.

1.1.6 INTERFACE (ENERGY CONVERSION/POWER TRANSMISSION)

This element covers the movable interface between the energy conversion subsystem and the power transmission subsystem. A 360 rotary joint and antenna elevation mechanism are required to maintain proper alignment of the transmitter with the ground receiving station. Included are structural items, mechanisms, power distribution, and maintenance hardware.

The interface is utilized to (1) transfer energy from the slip ring brushes to the antenna via transmission lines, and (2) act as the structural support member between the main satellite and the antenna. Elements of this movable interface (Figure 1.1-9) are described in the following subsections.

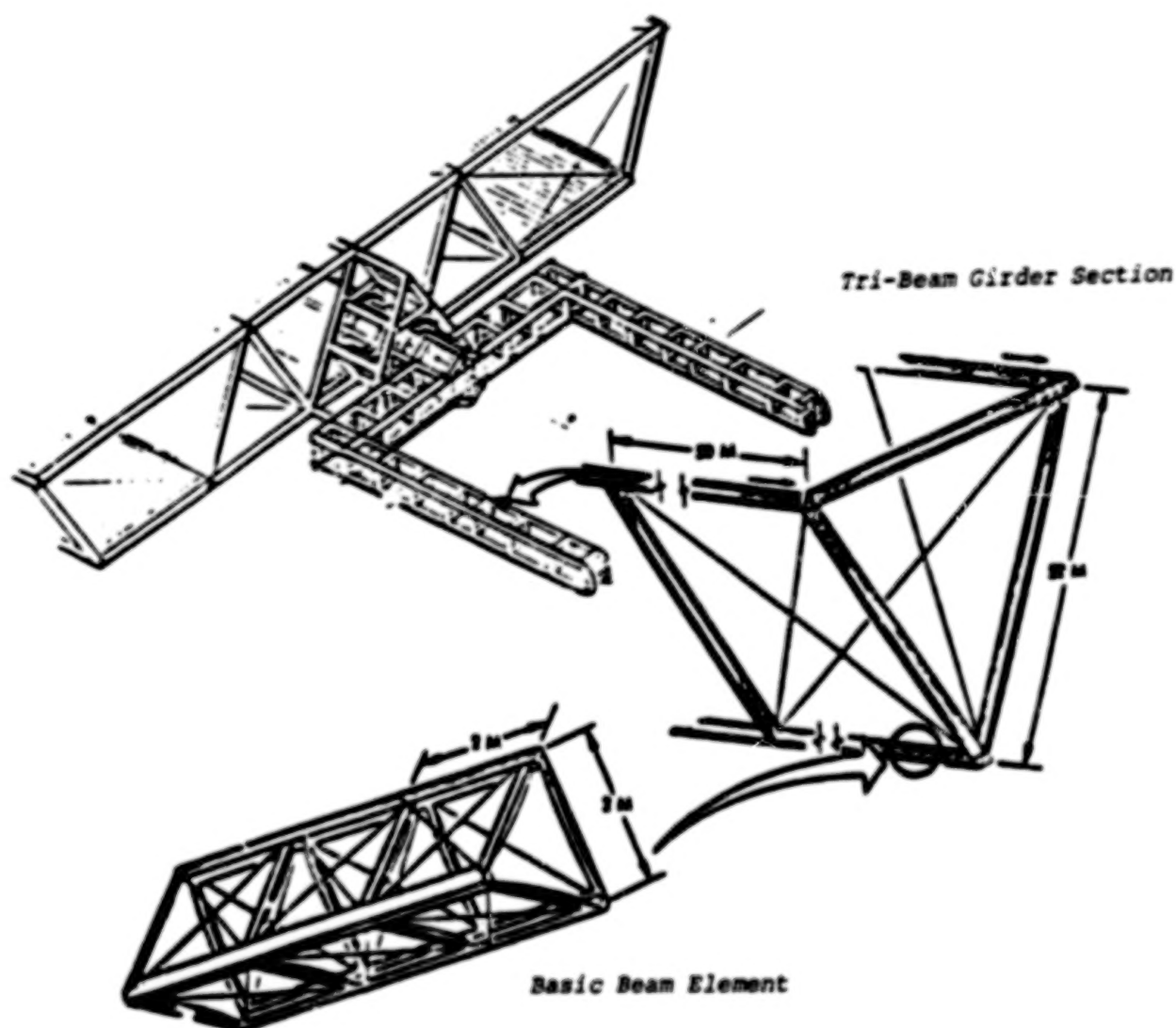


Figure 1.1-9. Energy Conversion/Power Transmission Interface

1.1.6.1 STRUCTURE

This element includes all members necessary to provide a mechanical interface between the primary structures of the energy conversion subsystem and the power transmission subsystem. It includes beams, beam couplers, cables, tensioning devices, and secondary structures. Excluded are elements of the drive assembly which are included in mechanisms (WBS 1.1.6.2).

1.1.6.1.1 Primary Structure

The basic supporting structure of the interface is included in this element. It is the primary load-carrying structure and does not include the secondary structure that is required to support transmission buses or equipment.

The SPS requirement for low thermal distortion, under high thermal stress, dictates the need for a material with a very low coefficient of expansion. The most likely candidate, at this time, is a graphite composite material.

The interface primary structure D&D CER was developed using graphite composite data obtained from NASA's Redstar Data Base. Tooling cost was excluded under the assumption that this cost would be incurred in the development of orbital fabrication equipment. The following data points were used:

- Space telescope shell
- HEAO optical bench
- ATS-F truss
- Shuttle payload bay doors

The interface structure ICI is the cost of raw materials only, since the costs associated with fabrication and assembly are charged against orbital assembly and support equipment (WBS 1.2). The structure ICI cost equation is based on raw composite material stock (pregregated graphite) cost. These material costs are based on vendor quotes obtained from Hercules, Fiberrite, and Union Carbide.

Range of Data:

D&D: 30.0 to 2000.0 kg
ICI: Unlimited

1.1.6.1.2 Secondary Structure

The secondary structure consists of the passive interface attachments between primary structure and operational subsystems. Structural members are made of aluminum with the ability to articulate, rotate, or otherwise support/allow motion between the primary structure and other subsystem elements.

This element includes all structure, consisting of mounting brackets, clamps, and installation structure required as an interface and mounting attachment points of components, assemblies, and subsystems. It also includes any structure required between two or more components or assemblies, slip ring brush and wire support brackets, and mechanism supports.

Development of the secondary structure CER for DDT&E and ICI was based on cost data contained in the MSFC Redstar Data Base. Data from a variety of launch vehicle and unmanned satellite programs were available and the applicable data points are listed below:

- S-IVB interstage
- S-IC forward skirt
- S-IC intertank
- Solar telescope housing assembly (ASM)
- Common mount assembly (ASM)
- Telescope gimbal assembly (ASM)
- Common mount actuators (ASM)
- Telescope gimbal actuators (ASM)
- Array platform elevation pointing actuator (ASM)
- UV gimbal mount actuators (ASM)
- UV instrument mount assembly (ASM)
- Solar array and boom structure (ATS-F)
- Squib interface unit (ATS-F)
- Interstage (Centaur)
- Nose shroud (Centaur)
- Fixed airlock shroud (Skylab)
- Payload shroud (Skylab)
- Pallet segment (Spacelab)
- OSO-1
- ATS-F
- S-II

Range of Data:

DDT&E: 6.0 to 15,000.0 kg
ICI: 6.0 to 15,000.0 kg

A review of these data points indicates extrapolations at the 6-kg level were based on the ATS-F solar array and boom structure, the Squib interface unit, ASM gimbal assemblies and actuators; whereas, the S-IC inner-tank, Centaur nose shroud, and interstages were extrapolated for the 10,000-kg category. The design and size of these items are considered more complex than that required for the SPS and, as a result, a complexity factor (CF) of 0.80 was established for the pilot plant/test article and the COTV. A CF of 0.70 was used for the satellite as the two prior vehicles will be completed and an improved data base will be available for the satellite secondary structure.

Tooling factors were identified by grouping secondary structure requirements for the annual production of satellites (WBS 1.1.1.1.2, Energy Conversion; WBS 1.1.2.1.2, Power Transmission; and WBS 1.1.6.1.2, Interface).

1.1.6.1.3 Cost Estimates

Primary and secondary structure costs are presented in Tables 1.1.6.1.1 and 1.1.6.1.2, respectively.

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.6.1.1 PRIMARY STRUCTURE

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|---|------------|------|----------------|--------------------|--------------|-----|-----|
| T= | 136000.000 | TF= | 1.000000 | CDCER= | 0.026910 | | |
| M= | 17000.0000 | UEM= | 0.0 | CDEXP= | 0.800000 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.000058 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.0 | Z3= | 60.000000 | BYEAR= | 1979 | | |
| DF= | 0.010000 | Z4= | 60.000000 | Z5= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | K6 | SUM TO 1.1.6.1 | | \$, MILLIONS | | |
| CD=CDCER X (T X DF)XX(CDEXP) X CF | | | | | 8.645 | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | | 0.994 | | |
| ORM = T / M | | | | | 8.000 | | |
| E = 1.0 + LOG(PHI) / LOG(2.0) | | | | | 1.000 | | |
| CTFU=(CLRM / E)X(ORM X Z1+.5)XX(E) -0.5XX(E) | | | | | 7.956 | | |
| CTB =(CLRM/E)X(ORM X Z3 + 0.5)XX(E) -0.5XX(E) | | | | 1 / Z3 | 7.956 | | |
| CIPS=CTB*Z4/Z2 | | | | | 7.956 | | |
| CRC1 =CTB X R | | | | | 0.0 | | |
| PRE-IUC CRC1 =CRC1 X Z6 | | | | | 0.0 | | |
| POST-IUC CRC1 =CRC1 X (1.0-Z6) | | | | | 0.0 | | |
| CUEM =OEM OR CTB*Z5/Z2/ENVR | | | | | 0.0 | | |

COMMENTS

1977 DATA ENTERED FOR CDCER, CICER, AND OEM WERE 0.023000 0.000050 0.0
OF CALCULATED INCUMINATION WITH 1.1.1.1.1, 1.1.2.1.1, & 1.1.9.1.15,
& 1.1.9.1.20

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.6.1.2 SECONDARY STRUCTURE

INPUT PARAMETERS

INPUT COEFFICIENTS

| | | | | | |
|------|------------|------|-----------|--------|----------|
| T= | 34000.0000 | TF= | 0.012296 | CDCER= | 0.182520 |
| M= | 5.000000 | UEM= | 0.0 | CDEXP= | 0.511000 |
| CF= | 0.700000 | Z1= | 1.000000 | CICER= | 0.118170 |
| PHI= | 0.980000 | Z2= | 60.000000 | CIEXP= | 0.355000 |
| R= | 0.001111 | Z3= | 62.000000 | BYEAR= | 1979 |
| DF= | 0.100000 | Z4= | 60.000000 | Z5= | 0.0 |
| | | | | Z6= | 0.0 |

CALCULATED VALUES

KG

SUM TO 1.1.6.1

\$, MILLIONS

$CU = CDCER \times (T \times DF) \times (CDEXP) \times CF$ 8.147

$CLRM = CICER \times (M) \times (CIEXP) \times CF \times TF$ 0.002

$\theta RM = T / M$ 6800.000

$E = 1.0 + \text{LOG}(PHI) / \text{LOG}(2.0)$ 0.971

$CTFU = (CLRM / E) \times ((\theta RM \times Z1 + 0.5) \times (E) - 0.5 \times (E))$ 9.753

$CTB = ((CLRM / E) \times ((\theta RM \times Z3 + 0.5) \times (E) - 0.5 \times (E))) / Z3$ 8.648

$LIPS = CTB \times Z4 / Z2$ 8.648

$CRC1 = CTB \times R$ 0.010

PRE-IUC $CRC1 = CRC1 \times Z6$ 0.0

POST-IUC $CRC1 = CRC1 \times (1.0 - Z6)$ 0.010

$CGEM = UEM \text{ OR } CTB \times Z5 / Z2 / ENVR$ 0.0

COMMENTS

1977 DATA ENTERED FOR CDCER, CICER, AND UEM WERE 0.156000 0.101000 0.0
COMBINE SATELLITE QUANTITIES FROM 1.1.1.1.2(117200 UNITS) & 1.1.2.1.2
(163000) FOR PHI DF & TF CALCULATIONS.

1.1.6.2 MECHANISMS

This element includes the components required to rotate and elevate power transmission (antenna) subsystem. Included are the drive ring, bearings, gear drives, and drive motors at the antenna connection.

Structural mechanisms consist of active and passive structural subassemblies that articulate, rotate, or otherwise cause or allow motion between the primary structure and other subsystem elements, or between subsystem elements themselves.

The ICI production cost CER was based on data provided by the following manufacturers:

| Manufacturer | Application |
|-----------------|---------------------------------|
| Poly-Scientific | High energy |
| Poly-Scientific | Radar |
| Electro-Tec | Navy destroyer propeller system |
| Electro-Tec | Satellite solar array |
| I.E.C. | Navy shipboard hoist |

Due to the difference in complexity and variations in specification requirements between ground- and space-qualified equipment, the following factors were applied:

| | |
|-------------------------------|-----|
| Complexity factor | × 3 |
| Specification uprating factor | × 3 |
| Total | × 9 |

Range of Data:

DDT&E: 6.0 to 15,000 kg
ICI: 6.0 to 15,000 kg

Cost estimates for this element are shown in Table 1.1.6.2

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.6.2 MECHANISMS - INTERFACE

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | | |
|---|------------|------|--------------|--------------------|----------|-----|-----|--------|
| T= | 33000.0000 | TF= | 1.000000 | CDCER= | 0.182520 | | | |
| M= | 1100.00000 | UEM= | 0.024999 | CDEXP= | 0.511000 | | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.000894 | | | |
| PHI= | 0.980000 | Z2= | 60.000000 | CIEXP= | 0.950000 | | | |
| R= | 0.002222 | Z3= | 64.000000 | BYEAR= | 1979 | | | |
| DF= | 0.050000 | Z4= | 60.000000 | Z5= | 0.0 | Z6= | 0.0 | |
| CALCULATED VALUES | | KG | SUM TO 1.1.6 | \$, MILLIONS | | | | |
| CD=CDCER X (T X DF)XX(CDEXP) X CF | | | | 8.043 | | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 0.693 | | | | |
| ORM =T / M | | | | 30.000 | | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 0.971 | | | | |
| CTFU=(CLRM / E)X(ORM X Z1+0.5)XX(E) -0.5XX(E) | | | | 19.337 | | | | |
| CTB =((CLRM/E)X(ORM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | | 1 / Z3 | | | | 17.173 |
| CIPS=CTB*Z4/Z2 | | | | 17.173 | | | | |
| CRC1 =CTB X R | | | | 0.038 | | | | |
| PRE-IUC CRC1 =CRC1 X Z6 | | | | 0.0 | | | | |
| POST-IUC CRC1 =CRC1 X (1.0-Z6) | | | | 0.038 | | | | |
| LOEM =DEM OR LTB*Z5/Z2/EWR | | | | 0.025 | | | | |
| COMMENTS | | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND UEM WERE 0.156000 0.000764 0.021367 | | | | | | | | |
| MECHANISMS ARE PRIMARILY PASSIVE GEARS AND BEARINGS AT ROTARY JOINT OF | | | | | | | | |
| 2000 KG. GIMBAL DRIVES & DRIVE MOTORS FOR THE ANTENNA ARE 31000 KG | | | | | | | | |

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1.1.6.3 POWER DISTRIBUTION

This element transmits electrical power from the rotary joint brushes to the microwave power transmission system (antenna). The PD&C system consists of power risers which are coupled to the pickup shoebrushes on the rotary joint and routed through the antenna support yolk (interface) to isolation switches on the antenna proper. There are two sets of slip rings, one positive and one negative; 15 brushes are needed per slip ring. Life expectancy of PD&C is 30 years with some replacements of slip ring brushes.

1.1.6.3.1 Conductors and Insulation

Power risers are sized to minimize the mass of itself and the satellite mass, considering power requirements, efficiency, and variation in resistivity with operating temperature. Power risers are made of multiple round aluminum (6101-T6) conductors with 1-mm kapton insulation, where 30 pairs of wire serve slip ring brushes.

1.1.6.3.2 Pickup Shoe Brushes

The pickup shoe brush portion of the rotary joint is included in the power distribution system of the interface segment. Sixty pickup shoe brush assemblies are required per satellite. The brush material is 75% MoS_2 and 25% Mo-Ta with a contact surface area per brush of 825.9 cm^2 . The shoe dimension in cm is $20.3\text{W} \times 25\text{H} \times 152\text{L}$ with a total weight of 17,000 kg for 60 pickup shoe brushes.

1.1.6.3.3 Power Distribution Cost Estimates

The CER presented in Table 1.1.1.4.3 was used for conductors and insulation. An extension of this CER was used for the brushes of 1.1.6.3.2. Cost estimates for interface power distribution are presented in Tables 1.1.6.3.1 and 1.1.6.3.2.

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.6.3.1 CONDUCTOR & INSULATION

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|------------|------|----------------|--------------------|----------|-----|-----|
| T= | 271000.000 | TF= | 1.000000 | CDCER= | 0.184860 | | |
| M= | 30.000000 | UGM= | 0.0 | CDEXP= | 0.297000 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.000005 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.0 | Z3= | 60.000000 | BYEAR= | 1979 | | |
| DF= | 0.100000 | Z4= | 60.000000 | Z5= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | RG | SUM TO 1.1.6.3 | 8, MILLIONS | | | |
| CD=CDCER X (T X DF)X(CDEXP) X CF | | | | 3.832 | | | |
| CLRM=CICER X (M)X(CIEXP) X CF X TF | | | | 0.000 | | | |
| ERM = T / M | | | | 9033.332 | | | |
| E = 1.0 + LOG(PHI) / LOG(2.0) | | | | 1.000 | | | |
| CTFU=(CLRM / E)X(ERM X Z1+0.5)X(E) -0.5X(E) | | | | 1.268 | | | |
| CTB =((CLRM/E)X(ERM X Z3 + 0.5)X(E) -0.5X(E)) | | | 1 / Z3 | 1.268 | | | |
| CIPS=CTB*Z4/Z2 | | | | 1.268 | | | |
| CRC1 =CTB X R | | | | 9.0 | | | |
| PRE-100 CRC1 =CRC1 X Z6 | | | | 0.0 | | | |
| POST-100 CRC1 =CRC1 X (1.0-Z6) | | | | 0.0 | | | |
| CUEM =UEM OR C1b*Z5/Z2/ENR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND UGM WERE | | | | 0.158000 | 0.000004 | 0.0 | |
| 30 PAIRS OF WIRE SERVING SLIPRINGS | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.6.3.2 SLIP RING BRUSHES

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|---|------------|------|-----------|--------------------|--------------|-----|-----|
| T= | 17000.0000 | TF= | 1.000000 | CDCER= | 0.184860 | | |
| M= | 142.000000 | UEM= | 0.0 | CDEXP= | 0.297000 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.000234 | | |
| PHI= | 0.950000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.005555 | Z3= | 70.000000 | RYEAR= | 1979 | | |
| DF= | 0.020000 | Z4= | 60.000000 | Z5= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | KL | SUM TO | 1.1.6.3 | \$, MILLIONS | | |
| CD=CDCER X (T X DF)XX(CDEXP) X CF | | | | | 1.044 | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | | 0.033 | | |
| FORM = T / M | | | | | 119.718 | | |
| E = 1.0 + LOG(PHI) / LOG(2.0) | | | | | 0.926 | | |
| CTFU=(CLRM / E)X((FORM X Z1+.5)XX(E) -0.5XX(E)) | | | | | 3.008 | | |
| CTB =((CLRM/E)X((FORM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | |) / Z3 | 2.201 | | |
| CIPS=CTB/Z2 | | | | | 2.201 | | |
| CRC1 =CTB X R | | | | | 0.012 | | |
| PRE-10C CRC1 =CRC1 X Z6 | | | | | 0.0 | | |
| POST-10C CHL1 =CHL1 X (1.0-Z6) | | | | | 0.012 | | |
| COEM =UEM OR CTB*Z5/Z2/RYEAR | | | | | 0.0 | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, LICER, AND UEM WERE | | | | 0.158000 | 0.000200 | 0.0 | |
| 30 SLIPRING SETS AT 4 SHOES EACH AVERAGE FOR M. | | | | | | | |

1.1.6.4 THERMAL CONTROL

This element includes any component used to modify the temperature of interface subsystem components. It includes coldplates, heat transfer, and radiator devices as well as insulation, thermal control coatings, and finishes. Excluded are paints or finishes applied to components during their manufacturing sequence. No thermal control requirements are defined for the interface at this time.

1.1.6.5 MAINTENANCE

This element provides for in-place repair or replacement of components and includes work stations, tracks, access ways, and *in situ* repair equipment on the interface (yoke) segment of the satellite.

Maintenance requirements are related to equipment and facilities needed to transport men and material to a work station on the interface segment of the satellite. Some of the same equipment required for maintenance at this location site is used commonly in the performance of work at other sites on the satellite.

Table 1.1.6.5 identifies the requirements. Cost estimates are provided in Tables 1.1.6.5.1, 1.1.6.5.2, and 1.1.6.5.3.

Table 1.1.6.5. Maintenance Requirements

| WBS NO. | MAINTENANCE ITEM DESCRIPTION | 1.1.6.5 INTERFACE |
|-----------|--|------------------------|
| 1.1.6.5.1 | "FREE-FLYERS" OR BARGE FOR CARGO AND PERSONNEL (COMMON USE ITEM) | .2 VEHICLE UTILIZATION |
| 1.1.6.5.2 | MANNED MANIPULATOR MODULE | 1 VEHICLE |
| 1.1.6.5.3 | TRACKS AND ACCESS WAYS | 24000 kg |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.6.5.1 MAINTENANCE - FREE FLYERS

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|---|------------|------|----------------|--------------------|----------|-----|-----|
| T= | 5000.00000 | TF= | 1.000000 | CDCER= | 0.0 | | |
| M= | 5000.00000 | UEM= | 0.0 | CDEXP= | 0.0 | | |
| CF= | 1.250000 | Z1= | 0.200000 | CICER= | 0.006784 | | |
| PHI= | 0.950000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.001111 | Z3= | 14.000000 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 12.000000 | 25= | 0.0 | 26= | 0.0 |
| CALCULATED VALUES | | AG | SUM TO 1.1.6.5 | \$,MILLIONS | | | |
| CU=CDCER X (T X DF)XX(CDEXP) X CF | | | | 0.0 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 42.398 | | | |
| FORM = T / M | | | | 1.000 | | | |
| E = 1.0 + LOG(PHI) / LOG(2.0) | | | | 0.926 | | | |
| CTFU=(CLRM / E)X((FORM X Z1+.5)XX(E) -0.5XX(E)) | | | | 8.810 | | | |
| CTB = ((CLRM/E)X((FORM X Z3 + 0.5)XX(E) -0.5XX(E))) | | | | 1 / Z3 | 37.186 | | |
| CIPS=CTB*Z4/Z2 | | | | 7.437 | | | |
| CRCI =CTB X R | | | | 0.041 | | | |
| PRE-IOC CRCI =CRCI X Z6 | | | | 0.0 | | | |
| POST-IOC CRCI =CRCI X (1.0-Z6) | | | | 0.041 | | | |
| CUEM =UEM OR CTB*Z5/Z2/ENVR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND UEM WERE | | | | 0.0 | 0.005798 | 0.0 | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.6.5.2 MANNED MANIPULATOR

INPUT PARAMETERS

| | | | |
|------|------------|------|-----------|
| T= | 3000.00000 | TF= | 1.000000 |
| M= | 3000.00000 | LEM= | 0.0 |
| CF= | 1.100000 | Z1= | 1.000000 |
| PHI= | 0.950000 | Z2= | 60.000000 |
| R= | 0.006666 | Z3= | 72.000000 |
| DF= | 1.000000 | Z4= | 60.000000 |

INPUT COEFFICIENTS

| | |
|--------|----------|
| CDCER= | 0.0 |
| CDEXP= | 0.0 |
| CICER= | 0.006784 |
| CIEXP= | 1.000000 |
| BYEAR= | 1979 |
| Z5= | 0.0 |
| Z6= | 0.0 |

CALCULATED VALUES

KG

SUM TO 1.1.6.5

\$,MILLIONS

CD=CDCER X (T X DF)XX(CDEXP) X CF

0.0

CLRM=CICER X (M)XX(CIEXP) X CF X TF

22.386

ORM = T / M

1.000

E = 1.0 + LOG(PHI) / LOG(2.0)

0.926

CTFU=(CLRM / E)X(ORM X Z1+0.5)XX(E) -0.5XX(E)

22.467

CTB = ((CLRM/E)X(ORM X Z3 + 0.5)XX(E) -0.5XX(E))

1 / Z3

17.553

CIPS=CTB*Z4/Z2

17.553

CRC1 = CTB X R

0.117

PRF-1UC CRC1 = CML1 X Z6

0.0

POST-1UC CRC1 = CRC1 X (1.0-Z6)

0.117

COEM = OGM OR CTB*Z5/Z2/ENVR

0.0

COMMENTS

1977 DATA ENTERED FOR CDCER, CICER, AND OGM WERE

0.0

0.005798

0.0

ROCKWELL S/S CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.6.5.3 TRACES & ACCESS WAYS

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|------------|------|----------------|--------------------|----------|-------|-----|
| T= | 24000.0000 | TF= | 1.000000 | CDCER= | 0.0 | | |
| M= | 24000.0000 | LEM= | 0.0 | COEXP= | 0.0 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.000050 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.0 | Z3= | 60.000000 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 60.000000 | Z5= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | KG | SUM TO 1.1.6.5 | \$,MILLIONS | | | |
| CD=CDCER X (T X DF)XX(COEXP) X CF | | | | 0.0 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 1.404 | | | |
| ORM = T / M | | | | 1.000 | | | |
| E = 1.0 + LOG(PHI) / LOG(2.0) | | | | 1.000 | | | |
| CIFU=(CLRM / E)X(ORM X Z1+.5)XX(E) -0.5XX(E) | | | | 1.404 | | | |
| CTB = ((CLRM/E)X(ORM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | | 1 / Z3 | | 1.404 | |
| CIPS=CTB*Z4/Z2 | | | | 1.404 | | | |
| CRC1 =CTB X R | | | | 0.0 | | | |
| PRE-IUC CRC1 =CRC1 X Z6 | | | | 0.0 | | | |
| POST-IUC CRC1 =CRC1 X (1.0-Z6) | | | | 0.0 | | | |
| CUEM =UEM OR CTB*Z5/Z2/ENVR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND OEM WERE | | | | 0.0 | 0.000050 | 0.0 | |

1.1.7 SYSTEMS TEST

This element includes the hardware, software, and activities required for ground-based systems test including qualification tests and other development tests involving two or more subsystems or assemblies. It includes the production, assembly, integration, and checkout of satellite system hardware into a full or partial system test article. It also encompasses the design, development, and manufacture of special test equipment, test fixtures, and test facilities that are not included in other elements such as ground support facilities. Also included are planning, documentation, and actual test operations.

Table 1.1.7.1 Documents DDT&E cost estimates for ground test hardware at 50% of satellite ICI costs. Operations for ground testing are assessed at another 50% of ICI costs as shown in Table 1.1.7.2.

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.7.1 SYSTEM GROUND TEST HARDWARE

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|----------|------|--------------|--------------------|------|-----|-----|
| T= | 0.0 | TF= | 1.000000 | CDCER= | 0.0 | | |
| M= | 0.0 | UEM= | 0.0 | CDEXP= | 0.0 | | |
| CF= | 0.0 | Z1= | 1.000000 | CICER= | 0.0 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 0.0 | | |
| R= | 0.0 | Z3= | 60.000000 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 60.000000 | Z5= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | SET | SUM TO 1.1.7 | \$,MILLIONS | | | |
| CD=CDCER X (T X DF)XX(CDEXP) X CF | | | | 2489.092 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 0.0 | | | |
| ORM = T / M | | | | 0.0 | | | |
| E = 1.0 + LOG(PHI) / LOG(2.0) | | | | 0.0 | | | |
| CIFU=(CLRM / E)X((ORM X Z1+.5)XX(E) -0.5XX(E)) | | | | 0.0 | | | |
| CTB =(1CLRM/E)X((ORM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | 1 / Z3 | 0.0 | | | |
| CIPS=CTB*Z4/Z2 | | | | 0.0 | | | |
| CRCI =CTB X R | | | | 0.0 | | | |
| PRE-IOC CRCI =CRCI X Z6 | | | | 0.0 | | | |
| POST-IOC CRCI =CRCI X (1.0-Z6) | | | | 0.0 | | | |
| CUGM =UEM OR CTB*Z5/Z2/ENYR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CULER, CIGER, AND OGM WERE | | | | 0.0 | 0.0 | 0.0 | |
| DDIGE = 50% OF SATELLITE ICI | | | | | | | |

ROCKWELL SPS LR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.7.2 SYSTEM GROUND TEST OPERATIONS

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|----------|------|--------------|--------------------|------|-----|-----|
| T= | 0.0 | TF= | 1.000000 | CDCER= | 0.0 | | |
| M= | 0.0 | LEM= | 0.0 | CDEXP= | 0.0 | | |
| CF= | 0.0 | Z1= | 1.000000 | CICER= | 0.0 | | |
| Phi= | 1.000000 | Z2= | 60.000000 | CIEXP= | 0.0 | | |
| R= | 0.0 | Z3= | 60.000000 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 60.000000 | Z5= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | SET | SUM TO 1.1.7 | \$,MILLIONS | | | |
| CU=CDCER X (T X DF)XX(CDEXP) X CF | | | | 2489.092 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 0.0 | | | |
| FORM = T / M | | | | 0.0 | | | |
| E = 1.0 + LOG(PHI) / LOG(2.0) | | | | 0.0 | | | |
| CTFU=(CLRM / E)X(1+FORM X Z1+0.5)XX(E) -0.5XX(E) | | | | 0.0 | | | |
| CTB =((CLRM/E)X(1+FORM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | |) / Z3 | | | |
| CIPS=CTB*24/Z2 | | | | 0.0 | | | |
| CRCI =CTB X R | | | | 0.0 | | | |
| PRE-IUC CRCI =CRCI X Z6 | | | | 0.0 | | | |
| POST-IUC CRCI =CRCI X (1.0-Z6) | | | | 0.0 | | | |
| COEM =OEM OR CTB*25/Z2/E*NR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CULFR, CICEH, AND OEM WERE | | | | 0.0 | 0.0 | 0.0 | |
| DDT&E TEST OPS = 50% OF SATELLITE ICI | | | | | | | |

1.1.8 GROUND SUPPORT EQUIPMENT (GSE)

This element includes all ground-based hardware required in support of handling, servicing, test, and checkout of satellite subsystems. It also includes special hardware required for simulations and training.

Costs for design, development, manufacture, acceptance, qualification, and maintenance of the GSE equipment are included. It is recognized that various equipments can serve multipurposes. For example, a developmental mockup may later serve as a training aid after it has served its original purposes. In these instances, the acquisition cost is charged to the original or first-purpose use, and subsequent usage will incur only recurring operations and maintenance costs.

GSE costs from several launch vehicle, manned spacecraft and unmanned satellites were analyzed to determine their applicability to SPS GSE requirements. From these data, a percentage factor was developed which was used to estimate SPS ground support equipment costs. This factor is expressed by the equation $C_D = 0.10 (C)$; where C = DDT&E cost of the satellite system. See table 1.1.8.

ROCKWELL SPS CN-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.B GROUND SUPPORT EQUIPMENT- SATELLITE

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|----------|------|------------|--------------------|-----|------|-----|
| T= | 0.0 | TF= | 1.000000 | CDCER= | 0.0 | | |
| M= | 0.0 | UEM= | 0.0 | COEXP= | 0.0 | | |
| CF= | 0.0 | Z1= | 1.000000 | CICER= | 0.0 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 0.0 | | |
| R= | 0.0 | Z3= | 60.000000 | BYEAR= | | 1979 | |
| DF= | 1.000000 | Z4= | 60.000000 | Z5= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | SET | SUM TO 1.1 | \$,MILLIONS | | | |
| CU=CDCER X (T X DF)X(COEXP) X CF | | | | 629.907 | | | |
| CLRM=CICER X (M)X(CIEXP) X CF X TF | | | | 0.0 | | | |
| EORM =T / M | | | | 0.0 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 0.0 | | | |
| CIFU=(CLRM / E)X(EORM X (1+.5)X(E) -0.5X(E)) | | | | 0.0 | | | |
| CTB =(CLRM/E)X(EORM X (Z3 + 0.5)X(E) -0.5X(E)) | | | 1 / Z3 | 0.0 | | | |
| CIPS=CTB*24/22 | | | | 0.0 | | | |
| CRC1 =CTB X R | | | | 0.0 | | | |
| PRE-IOC CRC1 =CRC1 X Z6 | | | | 0.0 | | | |
| POST-IOC CRC1 =CRC1 X (1.0-Z6) | | | | 0.0 | | | |
| COEM =OEM OR CTB*25/22/ENTR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND OEM WERE | | | | 0.0 | 0.0 | 0.0 | |
| DDTGE USE = 10% OF SATELLITE DDTGE ABOVE | | | | | | | |

1.1.9 SPS PILOT PLANT AND TEST ARTICLE

This element of the SPS program consists of a pilot plant and test article to serve as a proof-of-concept (POC) for the Rockwell SPS reference configuration. It will have the objective to minimize overall costs of the program, and to maximize concept/system development activities before the commitment of extraordinary funds. At this same time, it is intended to validate space system technologies and to integrate energy conversion, interface, and power transmission segments of the SPS satellite. This leads to an operational capability that will combine program elements, transportation system interfaces, space construction techniques, and ground system operations.

Fundamentally, a total system proof of concept entails component manufacturing, launch to orbit, space construction, and system operation measurable to a performance specification. More specifically, it must involve validation from orbit of key technology issues. Where deemed necessary, full-scale system elements are to be employed. Funding for the demonstration must meet two basic requirements. First, the overall funding level shall be reasonably low, and achieve results commensurate with desired goals. Second, funding commitments shall also be conservative during the early time frame of the development programs, and still be compatible with the program schedule.

Completion of the SPS technology advancement phase of SPS research and development by 1987 will provide the technical confidence to proceed with full-scale pilot plant development and demonstration. Another objective of this development is to confirm test article performances and to demonstrate commercial viability of the SPS to sponsoring agencies, utility firms and potential consortiums, along with other interested groups that would ultimately interact with the production system and benefit from its capabilities. The proposed demonstration program, as shown in Figure 1.1-10, reflects, in general, the concept and phasing of this activity for cost-effective results and early design implementation.

The proof-of-concept test article would be constructed in LEO by using the Space Shuttle System (STS) for mass transfer and construction support. The construction of an antenna frame, initially to serve as a large structures demonstration article, is contemplated as the first step. LEO base facilities would be subsequently expanded to accommodate the buildup and fabrication of a single solar panel bay—equivalent in design to that contemplated for the satellite. A yoke is then fabricated at the solar bay and will serve as a mounting for the antenna frame. Subsequent assembly of antenna subarrays, solar panels, power distribution and conditioning, and other required subsystems will prepare the article for orbital checkout and initial test. The proof-of-concept satellite can be expanded by the addition of solar panel bays, and antenna subarrays as may be required for further LEO testing or as considered necessary for GEO test verification and operational checkout.

This element of the WBS covers those components of the pilot plant/test article program as needed to achieve end objectives. Subsequent sections describe cost and programmatic aspects in each area of the pilot plant as follows:

- Energy conversion
- Interface segment
- Power transmission
- Supporting subsystems
- Construction/crew requirements
- Test and verification activities
- Pilot plant propellants
- Space Shuttle transportation requirements
- Ground receiving facility

1.1.9.1 PILOT PLANT AND TEST ARTICLE

This element covers procurement of energy conversion, interface, power transmission, and supporting system segments of the pilot plant/test article.

The energy conversion segment consists of primary and secondary structure, mechanisms, solar blankets and concentrators, power distribution and conditioning, attitude control and stationkeeping systems, slip rings at the yoke interface, tracks and accessories, and batteries for auxiliary power.

The interface or yoke segment between the planar array and antenna includes primary and secondary structure, mechanisms, power distribution and slip ring brushes.

Power transmission/antenna design requirements identify primary and secondary structure, mechanisms, power distribution and conditioning equipment, klystron subarrays, thermal control, batteries, information management system, and reference frequency generation systems. These items are covered in tables of cost data and calculations.

CER's and cost estimates in this section are based on those as used in the particular section or system of earlier sections of this volume. However, adjustments and changes in the use of equations have been made to hopefully compensate for technology status and production/space experience during this earlier period or phase of the SPS scenario. Estimates are established for DDT&E as considered necessary to arrive at specific system configurations applicable to the pilot plant/test article.

Cost estimates for this vehicle are presented in the following tables:

| <u>Table</u> | <u>Segment</u> |
|-------------------------------|--------------------|
| 1.1.9.1.1 through 1.1.9.1.14 | Energy Conversion |
| 1.1.9.1.15 through 1.1.9.1.19 | Interface |
| 1.1.9.1.20 through 1.1.9.1.49 | Power Transmission |

1.1.9.2 PILOT PLANT/TEST ARTICLE OPERATIONS

This element of the pilot plant/test article program covers the transportation aspects, space construction, test validation, and pilot plant propellant requirements.

Cost estimates are presented as follows:

| <u>Table</u> | <u>Item</u> |
|--------------|------------------------------------|
| 1.1.9.2.1 | Space Shuttle Transportation (STS) |
| 1.1.9.2.2 | Construction Crew |
| 1.1.9.2.3 | Test Verification |
| 1.1.9.2.4 | Pilot Plant Propellants |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.9.1.1 PRIMARY STRUCTURE - E.C.

INPUT PARAMETERS

| | | | |
|------|------------|------|-----------|
| T= | 41000.0000 | TF= | 1.000000 |
| M= | 15.000000 | UEM= | 0.0 |
| CF= | 1.000000 | Z1= | 1.000000 |
| PHI= | 1.000000 | Z2= | 60.000000 |
| R= | 0.0 | Z3= | 0.0 |
| DF= | 0.500000 | Z4= | 0.0 |

INPUT COEFFICIENTS

| | |
|--------|----------|
| CDCER= | 0.026910 |
| CDEXP= | 0.800000 |
| CICER= | 0.000058 |
| CIEXP= | 1.000000 |
| BYEAR= | 1979 |
| Z5= | 0.0 |
| Z6= | 0.0 |

CALCULATED VALUES

KG

SUM TU 1.1.9.1

\$, MILLIONS

CD=CDCER X (1 X DF)XX(CDEXP) X CF

75.738

CLRM=CICER X (M)XX(CIEXP) X CF X TF

0.001

$\theta_{RM} = T / M$

2733.333

$E = 1.0 + \text{LOG}(\text{PHI}) / \text{LOG}(2.0)$

1.000

CTFU=(CLRM / E)X((θ_{RM} X Z1)+.5)XX(E) -0.5XX(E)

2.398

CTB=((CLRM/E)X((θ_{RM} X Z3 + 0.5)XX(E) -0.5XX(E))

) / Z3

0.0

CIPS=CTB*24/22

0.0

CRC1 =CTB X R

0.0

PRE-10C CRC1 =CRC1 X Z6

0.0

POST-10C CRC1 =CRC1 X (1.0-Z6)

0.0

CUEM =UEM OR CTB*25/22/ENVR

0.0

COMMENTS

1977 DATA ENTERED FOR CDCER, CICER, AND UEM WERE 0.023000 0.000050 0.0
COMPOSITE MATERIAL. OF CALCULATION CONSIDERS PRIMARY STRUCTURE
FROM 1.1.9.1.15

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.9.1.2 SECONDARY STRUCTURE - E.C.

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|------------|------|----------------|--------------------|----------|-----|-----|
| T= | 56000.0000 | TF= | 0.032172 | CDCER= | 0.162520 | | |
| M= | 5.000000 | UEM= | 0.0 | CDEXP= | 0.511000 | | |
| CF= | 0.800000 | Z1= | 1.000000 | CICER= | 0.118170 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 0.355000 | | |
| R= | 0.0 | Z3= | 0.0 | BYEAR= | 1979 | | |
| DF= | 0.500000 | Z4= | 60.000000 | 25= | 0.0 | 26= | 0.0 |
| CALCULATED VALUES | | NO | SUM TO 1.1.9.1 | \$, MILLIONS | | | |
| CU=CDCER X (T X DF)XX(CDEXP) X CF | | | | 27.346 | | | |
| CLRM=CICER X (M)X(CIEXP) X CF X TF | | | | 0.005 | | | |
| ORM = T / M | | | | 11200.000 | | | |
| E = 1.0 + LOG(PHI) / LOG(2.0) | | | | 1.000 | | | |
| CTFU=(CLRM / E)X(ORM X Z1+.5)XX(E) -0.5XX(E)) | | | | 60.315 | | | |
| CTB = ((CLRM/E)X(ORM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | |) / Z3 | | | |
| CIPS=CTB*Z4/Z2 | | | | 0.0 | | | |
| CRC1 =CTB X R | | | | 0.0 | | | |
| PRE-IOC CRC1 =CRC1 X Z6 | | | | 0.0 | | | |
| POST-IOC CRC1 =CRC1 X (1.0-Z6) | | | | 0.0 | | | |
| CUEM =UEM OR CTH*Z5/Z2/LNYR | | | | 0.0 | | | |

COMMENTS

1977 DATA ENTERED FOR CDCER, CICER, AND UEM WERE 0.156000 0.101000 0.0
COMBINE OTHER PRECURSOR QUANTITIES FROM 1.1.9.1.16 & 1.1.9.1.21 FOR
DF & TF CALCULATIONS. COVERS THRUSTER STRUCTURES PLUS SECONDARY
STRUCTURE

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.9.1.3 MECHANISMS - PRECURSOR E.C.

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|------------|------|----------------|--------------------|----------|-----|-----|
| T= | 10000.0000 | TF= | 1.000000 | CDCER= | 0.182520 | | |
| M= | 110.000000 | LEM= | 0.0 | CDEXP= | 0.511000 | | |
| CF= | 1.500000 | Z1= | 1.000000 | CICER= | 0.000894 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 0.950000 | | |
| R= | 0.0 | Z3= | 0.0 | BYEAR= | 1979 | | |
| DF= | 0.500000 | Z4= | 60.000000 | 25= | 0.0 | 26= | 0.0 |
| CALCULATED VALUES | | KG | SUM TO 1.1.9.1 | \$, MILLIONS | | | |
| CU=CDCER X (T X DF)XX(CDEXP) X CF | | | | 21.261 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 0.117 | | | |
| ORM =T / M | | | | 90.909 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 1.000 | | | |
| CTFU=(CLRM / E)X((ORM X Z1+.5)XX(E) -0.5XX(E)) | | | | 10.600 | | | |
| CTB =((CLRM/E)X((ORM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | |) / Z3 | | | |
| CIPS=CTB*Z4/Z2 | | | | 0.0 | | | |
| CRC1 =CTB X R | | | | 0.0 | | | |
| PRE-IGC CRC1 =CRC1 X Z6 | | | | 0.0 | | | |
| POST-IGC CRC1 =CRC1 X (1.0-Z6) | | | | 0.0 | | | |
| LOEM =UEM OR CTR*Z5/Z2/ENYR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND UEM WERE 0.156000 0.000764 C.0 | | | | | | | |
| INCLUDES 4000 KG FOR ROTARY JOINT MOTORS/DEVICES, TENSION DEVICES, | | | | | | | |
| PAYLOAD LATCHES, THRUSTOR GIMBOLS | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.9.1.4 CONCENTRATOR - E.C.

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|------------|--------|------------|--------------------|----------|----------|-----|
| T= | 1823200.00 | TP= | 1.000000 | CDCER= | | 0.031590 | |
| M= | 474500.000 | UEM= | 0.0 | CDEXP= | | 0.394000 | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | | 0.000004 | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | | 0.950000 | |
| R= | 0.0 | Z3= | 0.0 | RYEAR= | | 1979 | |
| DF= | 1.000000 | Z4= | 0.0 | Z5= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | SUM | TU 1.1.9.1 | S, MILLIONS | | | |
| CU=CDCER X (T X DF)XX(CDEXP) X CF | | | | 9.254 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 0.866 | | | |
| ERM =T / M | | | | 3.842 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 1.000 | | | |
| CTFU=(CLRM / E)X((ERM X Z1+.5)XX(E) -0.5XX(E)) | | | | 3.329 | | | |
| CTB =((CLRM/E)X((ERM X Z3 + 0.5)XX(E) -0.5XX(E)) | |) / Z3 | | 0.0 | | | |
| CIPS=CTB*Z4/Z2 | | | | 0.0 | | | |
| CRC1 =CTB X R | | | | 0.0 | | | |
| PRE-IOC CRC1 =CRC1 X Z6 | | | | 0.0 | | | |
| POST-IOC CRC1 =CRC1 X (1.0-Z6) | | | | 0.0 | | | |
| CUEM =UEM OR CTB*Z5/Z2/ENR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND UEM WERE | | | | 0.027000 | 0.000003 | 0.0 | |
| DENSITY = .0181 KG PER SQ METER MASS = 33000 KG | | | | | | | |

ROCKWELL SP5 CH-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.9.1.5 SOLAR BLANKET -E.C.

INPUT PARAMETERS

| | | | |
|------|------------|------|-----------|
| T= | 549000.000 | TF= | 1.000000 |
| M= | 16250.0000 | UGM= | 0.0 |
| CF= | 1.200000 | Z1= | 1.000000 |
| PHI= | 1.000000 | Z2= | 60.000000 |
| R= | 0.0 | Z3= | 0.0 |
| DF= | 2.000000 | Z4= | 0.0 |

INPUT COEFFICIENTS

| | |
|--------|----------|
| CDCER= | 0.188838 |
| CDEXP= | 0.394000 |
| CICER= | 0.000078 |
| CIEXP= | 1.000000 |
| RYEAR= | 1979 |
| Z5= | 0.0 |
| Z6= | 0.0 |

CALCULATED VALUES

SG M

SUM 10 1.1.9.1

\$, MILLIONS

CD=CDCER X (T X DF)XX(CDEXP) X CF

67.440

CLRM=CICER X (M)XX(CIEXP) X CF X TF

1.717

WRM = T / M

52.000

E = 1.0 + LOG(PHI) / LOG(2.0)

1.000

CTFU=(CLRM / E)X((WRM X Z1+.5)XX(E) -0.5XX(E))

89.271

CTB = ((CLRM/E)X((WRM X Z3 + 0.5)XX(E) -0.5XX(E))

) / Z3

0.0

CIPS=CTB*Z5/Z2

0.0

CRCI =CTB X R

0.0

PRE-IOC CRCI =CRCI X Z6

0.0

POST-IOC LRLI =CHL1 X (1.0-Z6)

0.0

COEM =OEM OR C16*Z5/Z2/LNVR

0.0

COMMENTS

1977 DATA ENTERED FOR CDCER, CICER, AND UGM WERE 0.161400 0.000067 0.0
DENSITY - 0.2525 KG PER SG M, 2 SECTIONS, 26 PANELS EACH.
SECTION=650M X 73CM

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980

TABLE 1.1.9.1.6 SWITCHEAR & REGULATORS - E.C.

INPUT PARAMETERS

T= 9700.00000
M= 186.000000
CF= 1.500000
PHI= 1.000000
R= 0.0
DF= 2.000000

TF= 1.000000
UEM= 0.0
Z1= 1.000000
Z2= 60.000000
Z3= 0.0
Z4= 0.0

INPUT COEFFICIENTS

CDCER= 0.184860
CDEXP= 0.297000
CICER= 0.000468
CIEXP= 1.000000
BYEAR= 1979
25= 0.0 26= 0.0

CALCULATED VALUES

KG

SUM TO 1.1.9.1

\$, MILLIONS

$$CD = CDCER \times (T \times DF) \times (CDEXP) \times CF$$

5.205

$$CLRM = CICER \times (M) \times (CIEXP) \times CF \times TF$$

0.131

B-171

$$\theta RM = T / M$$

52.151

$$E = 1.0 + \text{LOG}(PHI) / \text{LOG}(2.0)$$

1.000

$$CIFU = (CLRM / E) \times ((\theta RM \times Z1 + 0.5) \times (E) - 0.5 \times (E))$$

6.809

$$CTB = ((CLRM / E) \times ((\theta RM \times Z3 + 0.5) \times (E) - 0.5 \times (E))) / Z3$$

0.0

$$CIPS = CTB \times Z4 / Z2$$

0.0

$$CRC1 = CTB \times R$$

0.0

$$\text{PRE-IDC } CRC1 = CRC1 \times Z6$$

0.0

$$\text{POST-IDC } CRC1 = CRC1 \times (11.0 - Z6)$$

0.0

$$CGEM = UEM \text{ OR } CTB \times Z5 / Z2 / ENVR$$

0.0

COMMENTS

1977 DATA ENTERED FOR CDCER, CICER, AND UEM WERE 0.150000 0.000400 0.0
1 BAY (2 SECTIONS) WITH 26 SETS PER SECTION. INCLUDES 2000 KG FOR
ACS POWER PROCESSING

ROCKWELL SPS CH-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.9.1.7 LO-VOLTAGE CONVERTERS - E.C

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|------------|------|----------------|--------------------|----------|-----|-----|
| T= | 300.000000 | TF= | 1.000000 | CDCER= | 0.184860 | | |
| M= | 6.000000 | DEM= | 0.0 | COEXP= | 0.297000 | | |
| CF= | 1.500000 | Z1= | 1.000000 | CICER= | 0.000468 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.0 | Z3= | 0.0 | BYEAR= | .979 | | |
| DF= | 2.000000 | Z4= | 60.000000 | 25= | 0.0 | 26= | 0.0 |
| CALCULATED VALUES | | K6 | SUM TO 1.1.9.1 | \$,MILLIONS | | | |
| CD=CDCER X (T X DF)XX(COEXP) X CF | | | | 1.854 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 0.004 | | | |
| EORM = T / M | | | | 50.000 | | | |
| E = 1.0 + LOG(PHI) / LOG(2.0) | | | | 1.000 | | | |
| CTFU=(CLRM / E)X((EORM X Z1+.5)XX(E) -0.5XX(E)) | | | | 0.213 | | | |
| CTB = ((CLRM/E)X((EORM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | | 1 / Z3 | | 0.0 | |
| CIPS=CTB*24/Z2 | | | | 0.0 | | | |
| CRC1 =CTB X R | | | | 0.0 | | | |
| PRE-IOC CRC1 =CRC1 X Z6 | | | | 0.0 | | | |
| POST-IOC CRC1 =CRC1 X (1.0-Z6) | | | | 0.0 | | | |
| CUBM =DEM OR CTB*24/Z2/24/6 | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND DEM WERE | | | | 0.158000 | 0.000400 | 0.0 | |
| 1 DAY (2 SECTIONS) WITH 26 SETS PER SECTION. | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.9.1.8 CONDUCTORS & INSULATION - E.C.

INPUT PARAMETERS

INPUT COEFFICIENTS

| | | | | | |
|------|------------|------|-----------|--------|----------|
| T= | 259000.000 | 1F= | 1.000000 | CDCER= | 0.184860 |
| M= | 4980.00000 | UEM= | 0.0 | CDEXP= | 0.297000 |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.000005 |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 1.000000 |
| R= | 0.0 | Z3= | 0.0 | BYEAR= | 1979 |
| DF= | 1.000000 | Z4= | 0.0 | 25= | 0.0 |
| | | | | 26= | 0.0 |

CALCULATED VALUES

K6

SUM TO 1.1.9.1

\$, MILLIONS

$$CD = CDCER \times (T \times DF) \times (CDEXP) \times CF$$

7.492

$$CLRM = CICER \times (M) \times (CIEXP) \times CF \times 1F$$

0.023

$$\theta RM = T / M$$

52.008

$$E = 1.0 + \log(PHI) / \log(2.0)$$

1.000

$$CTFU = (CLRM / E) \times ((\theta RM \times Z1 + 0.5) \times (E) - 0.5 \times (E))$$

1.212

$$CTB = ((CLRM / E) \times ((\theta RM \times Z3 + 0.5) \times (E) - 0.5 \times (E)))$$

1 / Z3

0.0

$$CIPS = CTB \times Z4 / Z2$$

0.0

$$CRC1 = CTB \times R$$

0.0

$$PRE-IOC \quad CRC1 = CRC1 \times Z6$$

0.0

$$POST-IOC \quad CRC1 = CRC1 \times (1.0 - Z6)$$

0.0

$$CUGM = UEM \text{ OR } CTB \times Z5 / Z2 / ENTR$$

0.0

COMMENTS

1977 DATA ENTERED FOR CDCER, CIEXP, AND UEM WERE

0.158000

0.000004

0.0

1 BAY (2 SECTIONS) WITH 26 SETS PER SECTION UN ARRAY

ROCKWELL SPS CM-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.9.1.9 ACS HARDWARE - E.C.

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|---|------------|------|----------------|--------------------|--------------|-----|-----|
| T= | 109000.000 | TF= | 0.300000 | CDCER= | 1.312739 | | |
| M= | 908.000000 | LEM= | 0.0 | COEXP= | 0.140000 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.066690 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 0.729000 | | |
| R= | 0.0 | Z3= | 0.0 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 0.0 | Z5= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | KG | SUM TO 1.1.9.1 | | \$, MILLIONS | | |
| C1=CDCER X (T X DF)XX(COEXP) X CF | | | | | 11.893 | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | | 2.868 | | |
| E = T / M | | | | | 120.044 | | |
| E = 1.0 + LOG(PHI) / LOG(2.0) | | | | | 1.000 | | |
| CIFU=(CLRM / E)X(1+RM X Z1+0.5)XX(E) -0.5XX(E) | | | | | 344.323 | | |
| CTR = (1+CLRM/E)X(1+RM X Z3 + 0.5)XX(E) -0.5XX(E) | | | 1 / Z3 | | 0.0 | | |
| CIPS=CTB*Z4/Z2 | | | | | 0.0 | | |
| CRC1 =CTB X R | | | | | 0.0 | | |
| PRE-IDC CRC1 =CRC1 X Z6 | | | | | 0.0 | | |
| POST-IDC CRC1 =CRC1 X (1.0-Z6) | | | | | 0.0 | | |
| COEM =DEM OR CTB*Z5/Z2/ENVR | | | | | 0.0 | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CLCR, CICER, AND DEM WERE 1.122000 0.057000 0.0 | | | | | | | |
| ITEM INCLUDES 120 THRUSTERS, TANKS, PROPELLANT LINES, AND ATTITUDE | | | | | | | |
| REFER. DETER. SYSTEM | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.9.1.10 ACS - CONDUCTORS & INSUL - E.C.

INPUT PARAMETERS

INPUT COEFFICIENTS

| | | | | | |
|------|------------|------|-----------|--------|----------|
| T= | 5920.00000 | IT= | 1.000000 | CDCER= | 0.184860 |
| M= | 1480.00000 | LEN= | 0.0 | CDEXP= | 0.297000 |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.000005 |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 1.000000 |
| R= | 0.0 | Z3= | 0.0 | BYEAR= | 1979 |
| DF= | 1.000000 | Z4= | 60.000000 | Z5= | 0.0 |
| | | | | Z6= | 0.0 |

CALCULATED VALUES

RG

SUM TU 1.1.9.1

9, MILLIONS

$CDC = CDCER \times IT \times DF \times (CDEXP)^{CF} \times CF$

2.439

$CLRM = CICER \times (M) \times (CIEXP)^{CF} \times CF \times TF$

0.007

$FORM = T / M$

4.000

$E = 1.0 + \text{LOG}(PHI) / \text{LOG}(2.0)$

1.000

$CTFU = (CLRM / E) \times (FORM \times Z1 + 0.5) \times (E - 0.5) \times (E)$

0.030

$CTB = ((CLRM / E) \times (FORM \times Z3 + 0.5) \times (E - 0.5) \times (E))$

$1 / Z3$

0.0

$CIPS = CTB \times Z4 / Z2$

0.0

$CRC1 = CTB \times R$

0.0

$PRE-IUC \quad CRC1 = CRC1 \times Z6$

0.0

$POST-IUC \quad CRC1 = CRC1 \times (1.0 - Z6)$

0.0

$CUGM = UGM \text{ OR } CTB \times Z5 / Z2 / ENVR$

0.0

COMMENTS

1979 DATA ENTERED FOR CDCER, CICER, AND OGM WERE 0.184860 0.000005 0.0
CONDUCTORS ASSOCIATED WITH ACS SYSTEM OF 4 THRUSTER COMPLEXES

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.9.1.11 ACS - BATTERIES - E.C.

INPUT PARAMETERS

INPUT COEFFICIENTS

| | | | | | |
|------|------------|------|-----------|--------|----------|
| T= | 152000.000 | TF= | 0.140000 | CDCER= | 0.040145 |
| M= | 50.000000 | UEM= | 0.0 | CDEXP= | 0.734000 |
| CF= | 1.500000 | Z1= | 1.000000 | CICER= | 0.030380 |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 0.241000 |
| R= | 0.0 | Z3= | 0.0 | BYEAR= | 1979 |
| DF= | 0.005000 | Z4= | 60.000000 | Z5= | 0.0 |
| | | | | Z6= | 0.0 |

CALCULATED VALUES

KG

SUM TU 1.1.9.1

\$, MILLIONS

$$CD = CDCER \times (T \times DF) \times (CDEXP) \times CF$$

7.839

$$CLRM = CICER \times (M \times (CIEXP) \times CF \times TF$$

0.016

$$ORM = 1 / M$$

3040.000

$$E = 1.0 + \text{LUG}(PHI) / \text{LUG}(2.0)$$

1.000

$$CTFU = (CLRM / E) \times (ORM \times Z1 + 0.5) \times (E) - 0.5 \times (E)$$

49.789

$$CTB = ((CLRM / E) \times (ORM \times Z3 + 0.5) \times (E) - 0.5 \times (E))$$

1 / Z3

0.0

$$CIPS = CTB \times Z4 / Z2$$

0.0

$$CRC1 = CTB \times R$$

0.0

$$\text{PRE-1UC } CRC1 = CRC1 \times Z6$$

0.0

$$\text{POST-1UC } CRC1 = CRC1 \times (1.0 - Z6)$$

0.0

$$CUEM = UEM \text{ OR } CTB \times Z5 / Z2 / ENVR$$

0.0

COMMENTS

1978 DATA ENTERED FOR CDCER, CICER, AND UEM WERE 0.037000 0.028000 0.0

50 KG PER CELL. CF CONSIDERS SODIUM CHLORIDE VS DATA BASE.

INCLUDES BATTERIES FOR E.C. SEGMENT, TF BASED ON 10 CELLS/BATTERY

ROCKWELL SPS CH-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.9.1.12 ACS - BATTERY PUEC - E.C.

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|------------|------|----------------|--------------------|----------|-----|-----|
| T= | 2000.00000 | TF= | 1.000000 | CDCER= | 0.057505 | | |
| M= | 250.000000 | LEM= | 0.0 | CDEXP= | 0.890000 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.013020 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 0.859000 | | |
| N= | 0.0 | Z3= | 0.0 | BYEAR= | 1979 | | |
| DF= | 0.250000 | Z4= | 60.000000 | Z5= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | K6 | SUM TO 1.1.9.1 | 8, MILLIONS | | | |
| LD=CDCER X (T X DF)XX(CDEXP) X LF | | | | 14.514 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 1.494 | | | |
| ERM =T / M | | | | 8.000 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 1.000 | | | |
| CTFU=(CLRM / E)X(ERM X Z1+0.5)XX(E) -0.5XX(E) | | | | 11.954 | | | |
| CTB =((CLRM/E)X(ERM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | |) / Z3 | | | |
| CIPS=CTB*24/22 | | | | 0.0 | | | |
| CRCI =CTB X R | | | | 0.0 | | | |
| PRE-IUC CRCI =CRCI X 26 | | | | 0.0 | | | |
| POST-IUC CRCI =CRCI X (1.0-26) | | | | 0.0 | | | |
| CUEM =0.6M OR L1E*25/22/ENTH | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1976 DATA ENTERED FOR CDCER, CICER, AND UEM WERE | | | | 0.053000 | 0.012000 | 0.0 | |
| SEE 1.1.9.1.35 FOR ADDITIONAL DUTIE | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.9.1.13 SLIPRINGS - PRECURSOR E.C.

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|------------|------|----------------|--------------------|----------|-----|-----|
| T= | 1500.00000 | TF= | 1.000000 | CDCER= | 0.182520 | | |
| M= | 750.00000 | DEM= | 0.0 | CDEXP= | 0.511000 | | |
| CF= | 2.000000 | Z1= | 1.000000 | CICER= | 0.000894 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 0.950000 | | |
| R= | 0.0 | Z3= | 0.0 | RYEAR= | 1979 | | |
| DF= | 3.000000 | Z4= | 0.0 | Z5= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | KG | SUM TO 1.1.9.1 | \$, MILLIONS | | | |
| CD=CDCER X (T X DF)XX(CDEXP) X CF | | | | 26.862 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 0.963 | | | |
| B-178- WRM = T / M | | | | 2.000 | | | |
| E = 1.0 + LOG(PHI) / LOG(2.0) | | | | 1.000 | | | |
| CTFU=(CLRM / E)X(WRM X Z1+.5)XX(E) -0.5XX(E) | | | | 1.926 | | | |
| CTB = ((CLRM/E)X(WRM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | 1 / Z3 | 0.0 | | | |
| CIPS=CTB*Z4/Z2 | | | | 0.0 | | | |
| CRC1 = CTB X R | | | | 0.0 | | | |
| PRE-10C CRC1 = CRC1 X Z6 | | | | 0.0 | | | |
| POST-10C CRC1 = CRC1 X (1.0-Z6) | | | | 0.0 | | | |
| LULN = JEM OR CID*Z5/Z2/ENTR | | | | 0.0 | | | |
| COMMENTS | | | | 0.156000 | 0.000764 | 0.0 | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND DEM WERE | | | | | | | |
| ONE FULL SLIP RING SET ONLY | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.9.1.14 TRACKS & ACCESS WAYS - E.C.

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|------------|------|----------------|--------------------|----------|-----|-----|
| T= | 35000.0000 | TF= | 1.000000 | CDCER= | 0.0 | | |
| M= | 100.000000 | UGM= | 0.0 | CDEXP= | 0.0 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.000058 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.0 | Z3= | 0.0 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 60.000000 | 25= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | KG | SUM TO 1.1.9.1 | \$,MILLIONS | | | |
| CU=CDCER X (1 X DF)XX(CDEXP) X CF | | | | 0.0 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 0.006 | | | |
| FORM =1 / M | | | | 350.000 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 1.000 | | | |
| CTFU=(CLRM / E)X((FORM X Z1+.5)XX(E) -0.5XX(E)) | | | | 2.047 | | | |
| CTB =((CLRM/E)X((FORM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | | 1 / Z3 | | 0.0 | |
| CIPS=CTB*24/22 | | | | 0.0 | | | |
| CRC1 =CTB X R | | | | 0.0 | | | |
| PRE-10C CRC1 =CRC1 X Z6 | | | | 0.0 | | | |
| POST-10C CRC1 =CRC1 X (1.0-Z6) | | | | 0.0 | | | |
| CGEM =UGM OR CTB*25/22/ENYR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND UGM WERE 0.0 0.000050 0.0 | | | | | | | |
| TOTAL OF 35000 KG COVERS 3000 KG FOR E.C. AND 32000 KG FOR INTERFACE | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.9.1.15 PRIMARY STRUCTURE - INTERFACE

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|------------|------|----------------|--------------------|----------|-----|-----|
| T= | 136000.000 | TF= | 1.000000 | CDCER= | 0.026910 | | |
| M= | 200.000000 | UGM= | 0.0 | CDEXP= | 0.600000 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.000058 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | C1EXP= | 1.000000 | | |
| R= | 0.0 | Z3= | 0.0 | BYEAR= | 1979 | | |
| DF= | 0.500000 | Z4= | 0.0 | Z5= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | AG | SUM TO 1.1.9.1 | \$,MILLIONS | | | |
| CU=CDCER X (1 X DF)XX(CDEXP) X CF | | | | 197.661 | | | |
| CLRM=CICER X (M)XX(C1EXP) X CF X TF | | | | 0.012 | | | |
| ORM = T / M | | | | 680.000 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 1.000 | | | |
| CTFU=(CLRM / E)X((ORM X Z1+0.5)XX(E) -0.5XX(E)) | | | | 7.956 | | | |
| CTB =((CLRM/E)X((ORM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | 1 / Z3 | 0.0 | | | |
| CIPS=CTB*Z4/Z2 | | | | 0.0 | | | |
| CRC1 =CTB X R | | | | 0.0 | | | |
| PRE-IUC CRC1 =CRC1 X Z6 | | | | 0.0 | | | |
| POST-IUC CRC1 =CRC1 X (1.0-Z6) | | | | 0.0 | | | |
| CUM =UGM OR CTB*Z5/Z2/ENR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CULER, CICER, AND UGM WERE 0.023000 0.000050 0.0 | | | | | | | |
| COMPOSITE MATERIAL. IF CALCULATION CONSIDERS PRIMARY STRUCTURE | | | | | | | |
| FROM 1.1.9.1.1 | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.9.1.16 SECONDARY STRUCTURE - INTERFACE

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|------------|------|----------------|--------------------|----------|-----|-----|
| T= | 6000.00000 | TF= | 0.032172 | CDCER= | 0.182520 | | |
| M= | 5.000000 | UEM= | 0.0 | CDEXP= | 0.511000 | | |
| CF= | 0.800000 | Z1= | 1.000000 | CICER= | 0.118170 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 0.355000 | | |
| R= | 0.0 | Z3= | 0.0 | BYEAR= | 1979 | | |
| DF= | 0.500000 | Z4= | 60.000000 | Z5= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | NO | SUM TO 1.1.9.1 | \$, MILLIONS | | | |
| CU=CDCER X (1 X DF)X(CDEXP) X C+ | | | | 8.734 | | | |
| CLRM=CICER X (M)X(CIEXP) X CF X TF | | | | 0.005 | | | |
| E=RM =T / M | | | | 1200.000 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 1.000 | | | |
| CTFU=(CLRM / E)X(1+RM X Z1+0.5)X(E) -0.5X(E) | | | | 6.462 | | | |
| CTB =((CLRM/E)X(1+RM X Z3 + 0.5)X(E) -0.5X(E)) | | | | 1 / Z3 | | 0.0 | |
| CIPS=CTB*Z4/Z2 | | | | 0.0 | | | |
| CRC1 =CTB X R | | | | 0.0 | | | |
| PRE-IDC CRC1 =CRC1 X Z6 | | | | 0.0 | | | |
| POST-IDC LRL1 =CRC1 X (1.0-Z6) | | | | 0.0 | | | |
| CUEM =UEM OR C10*Z5/Z2/ENVR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND UEM WERE 0.156000 0.101000 0.0 | | | | | | | |
| COMBINE OTHER PRELUSOR QUANTITIES FROM 1.1.9.1.2 & 1.1.9.1.21 | | | | | | | |
| FOR DF & TF CALCULATIONS. | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.9.1.17 MECHANISMS - INTERFACE

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|---|------------|------|----------------|--------------------|----------|-----|-----|
| T= | 33000.0000 | TF= | 1.000000 | CDCER= | 0.182520 | | |
| M= | 1100.00000 | UGM= | 0.0 | CDEXP= | 0.511000 | | |
| CF= | 1.500000 | Z1= | 1.000000 | CICER= | 0.000894 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 0.450000 | | |
| R= | 0.0 | Z3= | 0.0 | BYEAR= | 1979 | | |
| DF= | 0.100000 | Z4= | 0.0 | 25= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | KG | SUM TO 1.1.9.1 | \$,MILLIONS | | | |
| CD=CDCER X (T X DF)XX(CDEXP) X CF | | | | 17.193 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 1.039 | | | |
| WRM =T / M | | | | 30.000 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 1.000 | | | |
| CTFU=(CLRM / E)X((WRM X Z1+.5)XX(E) -0.5XX(E)) | | | | 31.176 | | | |
| CTR =((CLRM/E)X((WRM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | |) / Z3 | | 0.0 | |
| CIPS=CTR*Z4/Z2 | | | | 0.0 | | | |
| CRC1 =CTR X R | | | | 0.0 | | | |
| PRE-IGC CRC1 =CRC1 X Z6 | | | | 0.0 | | | |
| POST-IGC CRC1 =CRC1 X (1.0-Z6) | | | | 0.0 | | | |
| COEM =OEM OR CTR*Z5/Z2/ENVR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND UGM WERE 0.156000 0.000764 0.0 | | | | | | | |
| T INCLUDES 3100 KG FOR GIMBAL DRIVE MOTORS/DEVICES AND 2000 KG FOR GEARS & BEARINGS | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.9.1.18 CONDUCTORS & INSULATION - INTERFACE

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|------------|------|----------------|--------------------|----------|-----|-----|
| T= | 9500.00000 | TF= | 1.000000 | CDCER= | 0.184860 | | |
| M= | 1200.00000 | LEM= | 0.0 | CDEXP= | 0.297000 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.000005 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.0 | Z3= | 0.0 | RYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 0.0 | Z5= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | RG | SUM TO 1.1.9.1 | \$,MILLIONS | | | |
| CD=CDCER X (T X DF)XX(CDEXP) X CF | | | | 2.807 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 0.006 | | | |
| ORM = 1 / M | | | | 7.917 | | | |
| E = 1.0 + LOG(PHI) / LOG(2.0) | | | | 1.000 | | | |
| CTFU=(CLRM / E)X((ORM X Z1+0.5)XX(E) -0.5XX(E)) | | | | 0.044 | | | |
| CTB =((CLRM/E)X((ORM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | 1 / Z3 | 0.0 | | | |
| CIPS=CTB*Z4/Z2 | | | | 0.0 | | | |
| CRC1 =CTB' X R | | | | 0.0 | | | |
| PRE-IOC CRC1 =CRC1 X Z6 | | | | 0.0 | | | |
| POST-IOC CRC1 =CRC1 X (1.0-Z6) | | | | 0.0 | | | |
| CUEM =UEM OR CTB*Z5/Z2/RYEAR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND UEM WERE | | | | 0.158000 | 0.000004 | 0.0 | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.9.1.19 SLIPRING BRUSHES - PRECURSOR - INTERFACE

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|------------|------|----------------|--------------------|-------------|-----|-----|
| T= | 500.000000 | TF= | 1.000000 | CDCER= | 0.184860 | | |
| M= | 125.000000 | CEM= | 0.0 | CDEXP= | 0.297000 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.000234 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.0 | Z3= | 0.0 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 0.0 | 25= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | RG | SUM TO 1.1.9.1 | | \$ MILLIONS | | |
| CD=CDCER X (T X DF)X(CDEXP) X CF | | | | | 1.171 | | |
| CLRM=CICER X (M)X(CIEXP) X CF X TF | | | | | 0.029 | | |
| EORM = T / M | | | | | 4.000 | | |
| E = 1.0 + LOG(PHI) / LOG(2.0) | | | | | 1.000 | | |
| CTFU=(CLRM / E)X((EORM X Z1+0.5)X(E) -0.5X(E)) | | | | | 0.117 | | |
| CTB = ((CLRM/E)X((EORM X Z3 + 0.5)X(E) -0.5X(E)) | | | | 1 / Z3 | 0.0 | | |
| CIPS=CTB*Z4/Z2 | | | | | 0.0 | | |
| CRC1 =CTB X R | | | | | 0.0 | | |
| PRE-IUC CRC1 =CRC1 X Z6 | | | | | 0.0 | | |
| PUST-IUC CRC1 =CRC1 X (1.0-Z6) | | | | | 0.0 | | |
| CUGM =UGM ON CTB*Z5/Z2/ENYR | | | | | 0.0 | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND UGM WERE | | | | 0.158000 | 0.000200 | 0.0 | |
| SET OF BRUSHES FOR ONE SLIP RING ONLY | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.9.1.20 PRIMARY STRUCTURE - POWER TRANS

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|------------|------|----------------|--------------------|----------|-----|-----|
| T= | 23000.0000 | TF= | 1.000000 | CDCER= | 0.026910 | | |
| M= | 3800.00000 | UEM= | 0.0 | CDEXP= | 0.800000 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.000058 | | |
| PHI= | 1.000000 | Z2= | 0.000000 | CIEXP= | 1.000000 | | |
| R= | 0.0 | Z3= | 0.0 | BYEAR= | 1979 | | |
| DF= | 0.200000 | Z4= | 0.0 | Z5= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | K6 | SUM TO 1.1.9.1 | \$, MILLIONS | | | |
| CU=CDCER X (T X DF)XX(CDEXP) X CF | | | | 22.915 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 0.222 | | | |
| ARM = T / M | | | | 6.053 | | | |
| E = 1.0 + LOG(PHI) / LOG(2.0) | | | | 1.000 | | | |
| CTFU=(CLRM / E)X((ARM X Z1+.5)XX(E) -0.5XX(E)) | | | | 1.345 | | | |
| CTB =((CLRM/E)X((ARM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | 1 / Z3 | 0.0 | | | |
| CIPS=CTB*Z4/Z2 | | | | 0.0 | | | |
| CRC1 =CTB X R | | | | 0.0 | | | |
| PRE-IOC CRC1 =CRC1 X Z6 | | | | 0.0 | | | |
| POST-IOC CRC1 =CRC1 X (1.0-Z6) | | | | 0.0 | | | |
| UEM =UEM OR CTB*Z5/Z2/ENVR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND UEM WERE | | | | 0.023000 | 0.000050 | 0.0 | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.9.1.21 SECONDARY STRUCTURE - POWER TRANS

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|------------|------|----------------|--------------------|----------|-----|-----|
| T= | 29900.0000 | TF= | 0.032172 | CDCER= | 0.182520 | | |
| M= | 5.000000 | UGM= | 0.0 | CDEXP= | 0.511000 | | |
| CF= | 0.800000 | Z1= | 1.000000 | CICER= | 0.118170 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 0.355000 | | |
| R= | 0.0 | Z3= | 0.0 | BYEAR= | 1979 | | |
| DF= | 0.500000 | Z4= | 60.000000 | Z5= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | K6 | SUM TO 1.1.9.1 | \$,MILLIONS | | | |
| CD=CDCER X (1 X DF)XX(CDEXP) X CF | | | | 19.845 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 0.005 | | | |
| WRM =1 / M | | | | 5980.000 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 1.000 | | | |
| CTFU=(CLRM / E)X((WRM X Z1+.5)XX(E) -0.5XX(E)) | | | | 32.204 | | | |
| CTB =((CLRM/E)X((WRM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | 1 / Z3 | 0.0 | | | |
| CIPS=CTB*Z4/Z2 | | | | 0.0 | | | |
| CRC1 =CTB X R | | | | 0.0 | | | |
| PRE-IOC CRC1 =CRC1 X Z6 | | | | 0.0 | | | |
| POST-IOC CRC1 =CRC1 X (1.0-Z6) | | | | 0.0 | | | |
| CUEM =UGM OR CTB*Z5/Z2/ENR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND UGM WERE 0.156000 0.101000 0.0 | | | | | | | |
| COMBINE OTHER PRECURSOR QUANTITIES FROM 1.1.9.1.2 & 1.1.9.1.16 FOR | | | | | | | |
| DF & TF CALCULATIONS | | | | | | | |

ROCKWELL SPS CP-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.9.1.22 MECHANISMS - POWER TRANS.

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|------------|------|----------------|--------------------|-------------|-----|-----|
| T= | 2000.00000 | TF= | 1.000000 | CDCER= | 0.182520 | | |
| M= | 1000.00000 | UEM= | 0.0 | COEXP= | 0.511000 | | |
| CF= | 1.500000 | Z1= | 1.000000 | CICER= | 0.000894 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 0.950000 | | |
| R= | 0.0 | Z3= | 0.0 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 60.000000 | Z5= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | KG | SUM TO 1.1.9.1 | | \$ MILLIONS | | |
| CU=CDCER X (T X DF)XX(COEXP) X CF | | | | | 13.312 | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | | 0.949 | | |
| WRM = T / M | | | | | 2.000 | | |
| E = 1.0 + LOG(PHI) / LOG(2.0) | | | | | 1.000 | | |
| CIFU=(CLRM / E)X(WRM X Z1+.5)XX(E) -0.5XX(E) | | | | | 1.899 | | |
| CTB =((CLRM/E)X(WRM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | | 1 / Z3 | 0.0 | | |
| LIPS=CTB*Z4/Z2 | | | | | 0.0 | | |
| CRCI =CTB X R | | | | | 0.0 | | |
| PRE-IUC CRCI =CRCI X Z6 | | | | | 0.0 | | |
| POST-IUC CRCI =CRCI X (1.0-Z6) | | | | | 0.0 | | |
| COEM =UEM OR CTB*Z5/Z2/EWR | | | | | 0.0 | | |
| COMMENTS | | | | | | | |
| 1979 DATA ENTERED FOR CDCER, CICER, AND UEM WERE | | | | 0.182520 | 0.000894 | 0.0 | |
| GEARS & BEARINGS LOCATED AT ANTENNA TRUNNIONS | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.9.1.23 P.T. KLYSTRON SUBARRAY DOTE

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|------------|------|----------------|--------------------|----------|-----|-----|
| T= | 252000.000 | IF= | 1.000000 | CDCER= | 0.078390 | | |
| M= | 48.000000 | LEM= | 0.0 | CDEXP= | 0.507000 | | |
| CF= | 1.500000 | Z1= | 1.000000 | CICER= | 0.0 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 0.0 | | |
| R= | 0.0 | Z3= | 0.0 | BYEAR= | 1979 | | |
| DF= | 2.000000 | Z4= | 60.000000 | Z5= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | KW | SUM TU 1.1.9.1 | \$,MILLIONS | | | |
| CD=LDCER X (T X DF)XX(LDEXP) X CF | | | | 91.513 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 0.0 | | | |
| FORM =T / M | | | | 5250.000 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 1.000 | | | |
| CTFU=(CLRM / E)X(FORM X Z1+0.5)XX(E) -0.5XX(E) | | | | 0.0 | | | |
| CTB =((CLRM/E)X(FORM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | 1 / Z3 | 0.0 | | | |
| CIPS=CTB*24/22 | | | | 0.0 | | | |
| CRC1 =CTB X R | | | | 0.0 | | | |
| PRE-IOC CRC1 =CRC1 X Z6 | | | | 0.0 | | | |
| POST-IOC CRC1 =CRC1 X (1.0-Z6) | | | | 0.0 | | | |
| UEM =UEM OR CTR*25/22/ENVR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1979 DATA ENTERED FOR CDCER, CICER, AND UEM WERE | | | | 0.078390 | 0.0 | 0.0 | |
| 5250 KLYSTRONS ON PRECURSOR WITH OPERATION AT 48 KW PER TUBE | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.9.1.24 P.T. KLYSTROM WAVEGUIDE

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|------------|--------|-----------|--------------------|----------|--------------|-----|
| T= | 5250.00000 | TF= | 1.000000 | CDLER= | 0.0 | | |
| M= | 9.000000 | UEM= | 0.0 | CDEAP= | 0.0 | | |
| CF= | 1.200000 | Z1= | 1.000000 | CICER= | 0.000348 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.0 | Z3= | 0.0 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 60.000000 | Z5= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | PH SET | | SUM TO 1.1.9.1 | | \$, MILLIONS | |
| CU=CDLER X (T X DF)XX(CUEXP) X CF | | | | 0.0 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 0.004 | | | |
| ORM =T / M | | | | 583.333 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 1.000 | | | |
| CTFU=(CLRM / E)X((ORM X Z1+.5)XX(E) -0.5XX(E)) | | | | 2.192 | | | |
| CTB =((CLRM/E)X((ORM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | |) / Z3 | | 0.0 | |
| LIPS=CTB*Z4/Z2 | | | | 0.0 | | | |
| CRC1 =CTB X R | | | | 0.0 | | | |
| PRE-IDC CRC1 =CRC1 X Z6 | | | | 0.0 | | | |
| POST-IDC CRC1 =CRC1 X (1.0-Z6) | | | | 0.0 | | | |
| UEM =UEM OR CTR*Z5/Z2/ENR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1979 DATA ENTERED FOR CDLER, CICER, AND UEM WERE 0.0 0.000348 0.0 | | | | | | | |
| 5250 KLYSTRONS WITHIN 9 DENSITY GRADIENTS. ONE EQUIVALENT WAVEGUIDE EACH | | | | | | | |
| PER 5250 CUST ELEMENTS. | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.9.1.25 P.T. KLYSTRON HEATPIPES

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|------------|--------|----------------|--------------------|----------|-----|-----|
| T= | 5250.00000 | TF= | 1.000000 | CDCER= | 0.0 | | |
| M= | 9.000000 | UEM= | 0.0 | CDEXP= | 0.0 | | |
| CF= | 1.200000 | Z1= | 1.000000 | CICER= | 0.003006 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.0 | Z3= | 0.0 | RYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 60.000000 | Z5= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | PM SET | SUM TO 1.1.9.1 | 8, MILLIONS | | | |
| CD=CDCER X (T X DF)XX(CDEXP) X CF | | | | 0.0 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 0.032 | | | |
| FORM = T / M | | | | 583.333 | | | |
| E = 1.0 + LOG(PHI) / LOG(2.0) | | | | 1.000 | | | |
| CTFU=(CLRM / E)X((FORM X Z1+0.5)XX(E) -0.5XX(E)) | | | | 18.938 | | | |
| CIB = ((CLRM/E)X((FORM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | |) / Z3 | | | |
| CIPS=CIBXZ4/Z2 | | | | 0.0 | | | |
| CRC1 =CTB X R | | | | 0.0 | | | |
| PRE-IOC CRC1 =CRC1 X Z6 | | | | 0.0 | | | |
| POST-IOC CRC1 =CRC1 X (1.0-Z6) | | | | 0.0 | | | |
| UEM =UEM OR CIBXZ5/Z2/ENYK | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1979 DATA ENTERED FOR CULER, CILER, AND UEM WERE 0.0 0.003006 0.0 | | | | | | | |
| 5250 KLYSTRONS WITHIN 9 DENSITY GRADIENTS. ONE SET OF HEAT PIPES PER | | | | | | | |
| 5250 COST ELEMENTS | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.9.1.26 P.T. KLYSTRON P.M. ELEMENT

INPUT PARAMETERS

INPUT COEFFICIENTS

| | | | | | |
|------|------------|------|-----------|--------|----------|
| T= | 5250.00000 | TF= | 1.000000 | CDCER= | 0.0 |
| M= | 1.000000 | UGM= | 0.0 | CDEXP= | 0.0 |
| CF= | 1.200000 | Z1= | 1.000000 | CICER= | 0.002340 |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 1.000000 |
| R= | 0.0 | Z3= | 0.0 | BYEAR= | 1979 |
| DF= | 1.000000 | Z4= | 60.000000 | 25= | 0.0 |
| | | | | 26= | 0.0 |

CALCULATED VALUES

PM SET

SUM TO 1.1.9.1

\$, MILLIONS

CD=CDCER X (1 X DF)XX(CDEXP) X CF

0.0

CLRM=CICER X (M)XX(CIEXP) X CF X TF

0.003

ORM = T / M

5250.000

E = 1.0 + LOG(PHI) / LOG(2.0)

1.000

CTFU=(CLRM / E)X(ORM X Z1+0.5)XX(E) -0.5XX(E)

14.742

CTB =(CLRM/E)X(ORM X Z3 + 0.5)XX(E) -0.5XX(E)

1 / Z3

0.0

CIPS=CTB*Z4/Z2

0.0

CRC1 =CTB X R

0.0

PRE-IDC CRC1 =CHL1 X Z6

0.0

POST-IDC CRC1 =CRC1 X (1.0-Z6)

0.0

CUGM =UGM OR CTB*Z5/Z2/ENYR

0.0

COMMENTS

1979 DATA ENTERED FOR CDCER, CICER, AND UGM WERE

0.0

0.002340

0.0

5250 KLYSTRONS WITHIN 9 DENSITY GRADIENTS. ONE KLYSTRON POWER

MODULE PER COST ELEMENT

B-191

ROCKWELL SPS CK-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.9.1.27 P.T. KLYSTRON PHASE SHIFTERS

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|---|------------|--------|-----------|--------------------|----------|--------------|-----|
| T= | 5250.00000 | TF= | 1.000000 | CDCER= | 0.0 | | |
| M= | 1.000000 | UGM= | 0.0 | COEXP= | 0.0 | | |
| CF= | 1.200000 | Z1= | 1.000000 | CICER= | 0.001170 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.0 | Z3= | 0.0 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 60.000000 | Z5= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | PM SET | | SUM TO 1.1.9.1 | | \$, MILLIONS | |
| CU=CDCER X (T X DF)XX(COEXP) X CF | | | | | | 0.0 | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | | | 0.001 | |
| FORM = T / M | | | | | | 5250.000 | |
| E = 1.0 + LOG(PHI) / LOG(2.0) | | | | | | 1.000 | |
| CTFU=(CLRM / E)X((FORM X Z1+0.5)XX(E) -0.5XX(E)) | | | | | | 7.371 | |
| CTB = ((CLRM/E)X((FORM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | | 1 / Z3 | | 0.0 | |
| CIPS=CTB*Z4/Z2 | | | | | | 0.0 | |
| CRC1 =CTB X R | | | | | | 0.0 | |
| PRE-10C CRC1 =CRC1 X Z6 | | | | | | 0.0 | |
| POST-10C CRC1 =CRC1 X (1.0-Z6) | | | | | | 0.0 | |
| CUGM =UGM OR CIB*Z5/Z2/ENVR | | | | | | 0.0 | |
| COMMENTS | | | | | | | |
| 1979 DATA ENTERED FOR CDCER, CICER, AND UGM WERE 0.0 0.001170 0.0 | | | | | | | |
| 5250 KLYSTRON POWER MODULES. ONE PHASE SHIFTER PER KLYSTRON SET. | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.9.1.28 P. 1. KLYSTRON PH. CONTROL ELECTRONICS

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|---|------------|--------|-----------|--------------------|----------|--------------|-----|
| T= | 5250.00000 | TF= | 1.000000 | CDCER= | 0.0 | | |
| M= | 184.000000 | UEM= | 0.0 | CDEXP= | 0.0 | | |
| CF= | 1.200000 | Z1= | 1.000000 | CICER= | 0.000955 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.0 | Z3= | 0.0 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 60.000000 | 25= | 0.0 | 26= | 0.0 |
| CALCULATED VALUES | | PM SET | | SUM TO 1.1.9.1 | | \$, MILLIONS | |
| CU=CDCER X (T X DF)XX(CDEXP) X CF | | | | | | 0.0 | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | | | 0.211 | |
| E = T / M | | | | | | 28.533 | |
| E = 1.0 + LOG(PHI) / LOG(2.0) | | | | | | 1.000 | |
| CTFU=((CLRM / E)X((E X Z1+0.5)XX(E) -0.5XX(E))) | | | | | | 6.016 | |
| CTB=((CLRM/E)X((E X Z3 + 0.5)XX(E) -0.5XX(E))) | | | | | | 0.0 | |
| CTPS=CTB*Z4/Z2 | | | | | | 0.0 | |
| CRC1 =CTB X R | | | | | | 0.0 | |
| PRE-IOC CRC1 =CRC1 X 26 | | | | | | 0.0 | |
| POST-IOC CRC1 =CRC1 X (1.0-26) | | | | | | 0.0 | |
| CUEM =UEM OR CTB*Z5/Z2/ENVR | | | | | | 0.0 | |
| COMMENTS | | | | | | | |
| 1979 DATA ENTERED FOR CDCER, CICER, AND UEM WERE 0.0 0.000955 0.0 | | | | | | | |
| 5250 KLYSTRON POWER MODULES. ONE PHASE CONTROL ELECTRONICS PER | | | | | | | |
| 184 KLYSTRONS | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.9.1.29 P. T. KLYSTRON POWER DIVIDERS AND COMBINERS

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|------------|--------|----------------|--------------------|----------|-----|-----|
| T= | 5250.00000 | TF= | 1.000000 | CDCER= | 0.0 | | |
| M= | 184.000000 | UEM= | 0.0 | CDEXP= | 0.0 | | |
| CF= | 1.200000 | Z1= | 1.000000 | CICER= | 0.000152 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.0 | Z3= | 0.0 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 60.000000 | 25= | 0.0 | 26= | 0.0 |
| CALCULATED VALUES | | PM SET | SUM TO 1.1.9.1 | \$, MILLIONS | | | |
| CD=CDCER X (T X DF)XX(CDEXP) X CF | | | | 0.0 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 0.034 | | | |
| EORM = 1 / M | | | | 28.533 | | | |
| E = 1.0 + LOG(PHI) / LOG(2.0) | | | | 1.000 | | | |
| CTFU=(CLRM / E)X((EORM X 21+0.5)XX(E) -0.5XX(E)) | | | | 0.958 | | | |
| CTB = ((CLRM/E)X((EORM X 23 + 0.5)XX(E) -0.5XX(E)) | | | |) / 23 0.0 | | | |
| CIPS=CTB*24/22 | | | | 0.0 | | | |
| CRC1 =CTB X R | | | | 0.0 | | | |
| PRE-IUC CRC1 =CRC1 X 26 | | | | 0.0 | | | |
| POST-IUC CRC1 =CRC1 X (1.0-26) | | | | 0.0 | | | |
| CUEM =UEM OR CTB*25/22/ENH | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1979 DATA ENTERED FOR CDCER, CICER, AND UEM WERE 0.0 0.000152 0.0 | | | | | | | |
| 5250 KLYSTRON POWER MODULES. ONE SET OF POWER DIVIDERS AND COMBINERS | | | | | | | |
| PER 184 KLYSTRONS | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.9.1.30 ALYSTON SUBARRAY SYSTEM INTEGRATION

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|---|------------|--------|----------------|--------------------|----------|-----|-----|
| T= | 5250.00000 | TF= | 1.000000 | CDCEH= | 0.0 | | |
| M= | 20.399994 | UEM= | 0.0 | CDEXP= | 0.0 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.003986 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.0 | Z3= | 0.0 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 60.000000 | Z5= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | PM SET | SUM TO 1.1.9.1 | \$, MILLIONS | | | |
| CD=CDCEH X (T X DF)XX(CDEXP) X CF | | | | 0.0 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 0.081 | | | |
| ORM =T / M | | | | 257.353 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 1.000 | | | |
| CTFU=(CLRM / E)X((ORM X Z1+0.5)XX(E) -0.5XX(E)) | | | | 20.926 | | | |
| CTB =((CLRM/E)X((ORM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | | 1 / Z3 | 0.0 | | |
| CIPS=CTB*Z4/Z2 | | | | 0.0 | | | |
| CRCI =CTB X R | | | | 0.0 | | | |
| PRE-IOC CRCI =CRCI X Z6 | | | | 0.0 | | | |
| POST-IOC CRCI =CRCI X (1.0-Z6) | | | | 0.0 | | | |
| COEM =UEM OR CTR*Z5/Z2/ENYR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1979 DATA ENTERED FOR CDCEH, CICER, AND UEM WERE 0.0 0.003986 0.0 | | | | | | | |
| SYSTEM INTEGRATION OF ITEMS 1.1.9.1.24 THROUGH 1.1.9.1.29. | | | | | | | |
| APPROXIMATELY 257 SUBARRAYS ON THE AVERAGE. | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.9.1.31 PUEC - SW. CR. & REGULATORS - P.7.

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|------------|------|----------------|--------------------|----------|-----|-----|
| T= | 11400.0000 | TF= | 1.000000 | CDCER= | 0.184860 | | |
| M= | 9.000000 | LEM= | 0.0 | CDEXP= | 0.297000 | | |
| CF= | 1.500000 | Z1= | 1.000000 | CICER= | 0.000468 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.0 | Z3= | 0.0 | RYEAR= | 1979 | | |
| DF= | 3.000000 | Z4= | 60.000000 | Z5= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | RG | SUM TO 1.1.9.1 | 8, MILLIONS | | | |
| CD=CDCER X (T X DF)XX(CDEXP) X CF | | | | 6.159 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X T | | | | 0.006 | | | |
| ORM =T / M | | | | 1266.667 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 1.000 | | | |
| CTFU=(CLRM / E)X((ORM X Z1+0.5)XX(E) -0.5XX(E)) | | | | 8.003 | | | |
| CTB =((CLRM/E)X((ORM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | 1 / Z3 | 0.0 | | | |
| CIPS=CTB*Z4/Z2 | | | | 0.0 | | | |
| CRC1 =CTB X R | | | | 0.0 | | | |
| PRE-10C CRC1 =CRC1 X Z6 | | | | 0.0 | | | |
| POST-10C CRC1 =CRC1 X (1.0-Z6) | | | | 0.0 | | | |
| COEM =OEM OR CTB*Z5/Z2/ENR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1979 DATA ENTERED FOR CULER, CICER, AND LEM WERE | | | | 0.184860 | 0.000468 | 0.0 | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.9.1.32 P&C - M1 VOLTAGE CONVERT - P.T.

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|------------------|------------|------|-----------|--------------------|----------|-----|-----|
| T= | 44500.0000 | TF= | 1.000000 | CDCER= | 0.184860 | | |
| M= | 9.000000 | UEM= | 0.0 | CDEXP= | 0.297000 | | |
| CF= | 1.500000 | Z1= | 1.000000 | CICER= | 0.000244 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.0 | Z3= | 0.0 | BYEAR= | 1979 | | |
| DF= | 2.000000 | Z4= | 60.000000 | Z5= | 0.0 | Z6= | 0.0 |

CALCULATED VALUES K6 SUM TO 1.1.9.1 \$, MILLIONS

CD=CDCER X (1 X DF)XX(CDEXP) X CF 8.183

CLRM=CICER X (M)XX(CIEXP) X CF X TF 0.003

ERM = T / M 4944.441

E = 1.0 + LOG(PHI) / LOG(2.0) 1.000

CTFU=(CLRM / E)X((ERM X Z1+0.5)XX(E) -0.5XX(E)) 16.287

CTB =((CLRM/E)X((ERM X Z3 + 0.5)XX(E) -0.5XX(E)) 1 / Z3 0.0

CIPS=CTB*Z4/Z2 0.0

CRC1 =CTB X R 0.0

PRE-IUC CRC1 =CRC1 X Z6 0.0

POST-IUC CRC1 =CRC1 X (1.0-Z6) 0.0

COEM =OEM OR CIP*Z5/Z2/ENTR 0.0

CURRENTS

1979 DATA ENTERED FOR CDCER, CICER, AND UEM WERE 0.184860 0.000244 0.0

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.9.1.33 PUEC - LU VOLTAGE CONVERT - P.T.

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|------------|------|----------------|--------------------|----------|-----|-----|
| T= | 100.000000 | TF= | 1.000000 | CDCER= | 0.184860 | | |
| M= | 9.000000 | UEM= | 0.0 | CDEXP= | 0.297000 | | |
| CF= | 1.500000 | Z1= | 1.000000 | CICER= | 0.000468 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.0 | Z3= | 0.0 | RYEAR= | 1979 | | |
| DF= | 2.000000 | Z4= | 60.000000 | 25= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | RU | SUM TO 1.1.9.1 | \$, MILLIONS | | | |
| CD=CDCER X (T X DF)XX(CDEXP) X CF | | | | 1.338 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 0.006 | | | |
| ORM =T / M | | | | 11.111 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 1.000 | | | |
| CTFU=(CLRM / E)X(ORM X Z1+0.5)XX(E) -0.5XX(E)) | | | | 0.070 | | | |
| CTB =((CLRM/E)X(ORM X Z3 + 0.5)XX(E) -0.5XX(E)) | | |) / Z3 | 0.0 | | | |
| CIPS=CTB*Z4/Z2 | | | | 0.0 | | | |
| CRCI =CTB X R | | | | 0.0 | | | |
| PRE-10C CRCI =CRCI X Z6 | | | | 0.0 | | | |
| POST-10C CRLI =CRCI X (1.0-Z6) | | | | 0.0 | | | |
| COEM =OEM OR CIB*Z5/Z2/ENYR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1979 DATA ENTERED FOR CDCER, CICER, AND UEM WERE | | | | 0.184860 | 0.000468 | 0.0 | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.9.1.34 PUEC CONDUCTORS & INSULATION - P. 1.

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|------------|------|----------------|--------------------|----------|-----|-----|
| T= | 25800.0000 | TF= | 1.000000 | CDCER= | 0.184860 | | |
| M= | 9.000000 | UGM= | 0.0 | CDEXP= | 0.297000 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.000005 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.0 | Z3= | 0.0 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 0.0 | Z5= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | K | SUM TO 1.1.9.1 | \$,MILLIONS | | | |
| CU=CDCER X (T X DF)XX(CDEXP) X CF | | | | 3.777 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 0.000 | | | |
| ORM =T / M | | | | 2866.667 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 1.000 | | | |
| CTFU=(CLRM / E)X(ORM X Z1+0.5)XX(E) -0.5XX(E) | | | | 0.121 | | | |
| CTB =((CLRM/E)X(ORM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | 1 / Z3 | 0.0 | | | |
| CIPS=CTB*Z4/Z2 | | | | 0.0 | | | |
| CRC1 =CTB X R | | | | 0.0 | | | |
| PRE-IDC CRC1 =CRC1 X Z6 | | | | 0.0 | | | |
| POST-IDC CRC1 =CRC1 X (1.0-Z6) | | | | 0.0 | | | |
| CUGM =UGM OR C1B*Z5/Z2/ENYR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND UGM WERE | | | | 0.158000 | 0.000004 | 0.0 | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.9.1.35 BATTERIES - P.T. PRECURSOR

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|------------|------|----------------|--------------------|----------|-----|-----|
| T= | 6400.00000 | TF= | 1.000000 | CDCER= | 0.040145 | | |
| M= | 50.000000 | UEM= | 0.0 | CDEXP= | 0.734000 | | |
| CF= | 1.500000 | Z1= | 1.000000 | CICER= | 0.030380 | | |
| PHI= | 1.000000 | Z2= | 0.000000 | CIEXP= | 0.241000 | | |
| R= | 0.0 | Z3= | 0.0 | BYEAR= | 1979 | | |
| DF= | 0.800000 | Z4= | 0.0 | 25= | 0.0 | 26= | 0.0 |
| CALCULATED VALUES | | KG | SUM TO 1.1.9.1 | \$, MILLIONS | | | |
| CD=CDCER X (T X DF)XX(CDEXP) X CF | | | | 31.793 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 0.117 | | | |
| EORM =T / M | | | | 128.000 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 1.000 | | | |
| CTFU=(CLRM / E)X((EORM X Z1+0.5)XX(E) -0.5XX(E)) | | | | 14.974 | | | |
| CTB =((CLRM/E)X((EORM X Z3 + 0.5)XX(E) -0.5XX(E))) | | | | 1 / Z3 | | 0.0 | |
| CIPS=CTR*Z4/Z2 | | | | 0.0 | | | |
| CRC1 =CTB X R | | | | 0.0 | | | |
| PRE-IUC LRC1 =CRC1 X Z6 | | | | 0.0 | | | |
| PUST-IOL LRC1 =CRL1 X (1.0-Z6) | | | | 0.0 | | | |
| COEM =UEM OR CTB*Z5/Z2/E*NYR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1978 DATA ENTERED FOR CDCER, CICER, AND UEM WERE | | | | 0.037000 | 0.028000 | 0.0 | |
| 50 KG PER CELL - SODIUM CHLORIDE FOR ANTENNA | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.9.1.36 P.T. - BATTERY PDEC

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|------------|----------------|-----------|--------------------|----------|-----|-----|
| T= | 1600.00000 | TF= | 1.000000 | CDCER= | 0.057505 | | |
| M= | 250.000000 | UEM= | 0.0 | CDEXP= | 0.890000 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.013020 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 0.859000 | | |
| R= | 0.0 | Z3= | 0.0 | YEAR= | 1979 | | |
| DF= | 0.100000 | Z4= | 60.000000 | Z5= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | SUM TO 1.1.9.1 | | \$, MILLIONS | | | |
| CD=CDCER X (T X DF)X(CDEXP) X CF | | | | 5.265 | | | |
| CLRM=CICER X (M)X(CIEXP) X CF X TF | | | | 1.494 | | | |
| EORM =T / M | | | | 6.400 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 1.000 | | | |
| CTFU=(CLRM / E)X(EORM X Z1+0.5)X(E) -0.5X(E) | | | | 9.564 | | | |
| CTB =((CLRM/E)X(EORM X Z3 + 0.5)X(E) -0.5X(E)) | | | | 1 / Z3 | | 0.0 | |
| CIPS=CTB*Z4/Z2 | | | | 0.0 | | | |
| CRL1 =CTB X R | | | | 0.0 | | | |
| PRE-10C CRL1 =CRL1 X Z6 | | | | 0.0 | | | |
| POST-10C CRL1 =CRL1 X (1.0-Z6) | | | | 0.0 | | | |
| CUEM =UEM OR CTB*Z5/Z2/ENYR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1978 DATA ENTERED FOR CDCER, CICER, AND UEM WERE | | | | 0.053000 | 0.012000 | 0.0 | |

ROCKWELL SPS CP-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.9.1.37 THERMAL CONTROL - INSULATION - PRECURSOR R.T.

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|------------|------|----------------|--------------------|----------|-----|-----|
| T= | 26400.0000 | TF= | 0.046043 | CDCER= | 0.182520 | | |
| M= | 4.000000 | UEM= | 0.0 | CDEXP= | 0.511000 | | |
| IF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.118170 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 0.355000 | | |
| R= | 0.0 | Z3= | 0.0 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 0.0 | Z5= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | TO | SUM TO 1.1.9.1 | \$, MILLIONS | | | |
| CD=CDCER X (T X DF)XX(CDEXP) X C+ | | | | 33.170 | | | |
| CLRM=CICER X (M)XX(CIEXP) X C+ X TF | | | | 0.009 | | | |
| ORM =T / M | | | | 6600.000 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 1.000 | | | |
| CTFU=(CLRM / E)X((ORM X Z1+0.5)XX(E) -0.5XX(E)) | | | | 58.742 | | | |
| CTB =((CLRM/E)X((ORM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | |) / Z3 | | 0.0 | |
| CIPS=CTB*Z4/Z2 | | | | 0.0 | | | |
| CRC1 =CTB X R | | | | 0.0 | | | |
| PRE-100 CRC1 =CRC1 X Z6 | | | | 0.0 | | | |
| POST-100 CRC1 =CRC1 X (1.0-Z6) | | | | 0.0 | | | |
| LUEM =UEM OR CTB*Z5/Z2/LNR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDLER, CICER, AND UEM WERE | | | | 0.156000 | 0.101000 | 0.0 | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.9.1.3B REFERENCE FREQUENCY GENERATOR - PRECURSOR

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|----------|-----|----------------|--------------------|----------|-----|-----|
| Tn | 1.000000 | TFn | 1.000000 | CDCEr | 0.585000 | | |
| Nn | 1.000000 | UGM | 0.0 | CDExp | 1.000000 | | |
| CFn | 1.000000 | Z1n | 1.000000 | CICER | 0.117000 | | |
| PhIn | 1.000000 | Z2n | 0.000000 | CIExp | 1.000000 | | |
| Rn | 0.0 | Z3n | 0.0 | BYEAR | 1979 | | |
| DFn | 1.000000 | Z4n | 0.0 | Z5n | 0.0 | Z6n | 0.0 |
| CALCULATED VALUES | | SET | SUM TO 1.1.9.1 | \$, MILLIONS | | | |
| CD=CDCEr X (1 X DFn)X(CDExp) X CF | | | | 0.585 | | | |
| CLRM=CICER X (Nn)X(CIExp) X CF X TF | | | | 0.117 | | | |
| URM = T / N | | | | 1.000 | | | |
| E = 1.0 + LOG(PhIn) / LOG(2.0) | | | | 1.000 | | | |
| CTFU=(CLRM / E)X(URM X Z1+0.5)X(E) -0.5X(E) | | | | 0.117 | | | |
| CTB =((CLRM/E)X(URM X Z3 + 0.5)X(E) -0.5X(E)) | | | 1 / Z3 | 0.0 | | | |
| CIPS=CTB*Z4/Z2 | | | | 0.0 | | | |
| CRC1 =CTB X R | | | | 0.0 | | | |
| PRE-10C CRC1 =CRC1 X Z6 | | | | 0.0 | | | |
| POST-10C CRC1 =CRC1 X (1.0-Z6) | | | | 0.0 | | | |
| UGM =UGM OR CTB*Z5/Z2/ENYR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CLRM, CICER, AND UGM WERE | | | | 0.500000 | 0.100000 | 0.0 | |
| ENGINEERING ESTIMATE. UNIT SET FOR SATELLITE PRECURSOR | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.9.1.39 DIST. SYSTEM, CGAXIAL CABLE

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|---|------------|-----|----------|--------------------|----------------|-------------|-----|
| Ta | 8613.00000 | TFa | 1.000000 | CDCERa | 0.000035 | | |
| M | 261.000000 | UCM | 0.0 | COEXPa | 1.000000 | | |
| CFa | 1.000000 | Z1a | 1.000000 | CICERa | 0.000070 | | |
| Phi | 1.000000 | Z2a | 0.000000 | CIEXPa | 1.000000 | | |
| Ra | 0.0 | Z3a | 0.0 | BYEARa | 1979 | | |
| DFa | 1.000000 | Z4a | 0.0 | Z5a | 0.0 | Z6a | 0.0 |
| CALCULATED VALUES | | | | M | SUM TO 1.1.9.1 | S, MILLIONS | |
| CD=CDCER X (T X DF)XX(COEXP) X CF | | | | | | 0.302 | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | | | 0.018 | |
| E = T / M | | | | | | 33.000 | |
| E = 1.0 + LOG(Phi) / LOG(2.0) | | | | | | 1.000 | |
| CTFU=(CLRM / E)X(10RM X Z1+0.5)XX(E) -0.5XX(E) | | | | | | 0.605 | |
| CTB =(1(CLRM/E)X(10RM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | | | 1 / Z3 | 0.0 | |
| CIPS=CTB*24/Z2 | | | | | | 0.0 | |
| CRC1 =CTB X R | | | | | | 0.0 | |
| PRP=IUC CRC1 =CRC1 X Z6 | | | | | | 0.0 | |
| POST=IUC CRC1 =CRC1 X (1.0-Z6) | | | | | | 0.0 | |
| COCM =DEM OR CTB/Z5/Z2/ENYR | | | | | | 0.0 | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND DEM WERE | | | | 0.000030 | 0.000060 | 0.0 | |
| ENGINEERING ESTIMATE | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.9.1.40 DIST. SYSTEM DEVICES

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|------------|------|----------------|--------------------|----------|-----|-----|
| T= | 100.000000 | TF= | 1.000000 | CDCEP= | 0.000263 | | |
| M= | 2.000000 | UEM= | 0.0 | CDEXP= | 1.000000 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.005850 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.0 | Z3= | 0.0 | RYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 0.0 | Z5= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | NO | SUM TO 1.1.9.1 | \$ MILLIONS | | | |
| CU=CDCEP X (1 X DF)XX(CDEXP) X CF | | | | 0.026 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 0.012 | | | |
| EORM = T / M | | | | 50.000 | | | |
| E = 1.0 + LOG(PHI) / LOG(2.0) | | | | 1.000 | | | |
| LTFU=(CLRM / E)X(EORM X Z1+0.5)XX(E) -0.5XX(E) | | | | 0.585 | | | |
| CTB =((CLRM/E)X(EORM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | 1 / Z3 | 0.0 | | | |
| CIPS=CTB*Z4/Z2 | | | | 0.0 | | | |
| CRC1 =CTB X R | | | | 0.0 | | | |
| PRE-10C CRC1 =CRC1 X Z6 | | | | 0.0 | | | |
| POST-10C CRC1 =CRC1 X (1.0-Z6) | | | | 0.0 | | | |
| CDEM =DEM OR CTB*Z5/Z2/ENYR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCEP, CICER, AND DEM WERE | | | | 0.000225 | 0.005000 | 0.0 | |
| ENGINEERING ESTIMATE | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.9.1.41 P.T. - MASTER CONTROL COMPUTER - IMS/COM

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|---|------------|------|----------------|--------------------|----------|-----|-----|
| T= | 1000.00000 | TF= | 1.000000 | CDCER= | 0.740610 | | |
| M= | 500.000000 | UEM= | 0.0 | CDEXP= | 0.521000 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.201240 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 0.535000 | | |
| R= | 0.0 | Z3= | 0.0 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 60.000000 | Z5= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | K6 | SUM TO 1.1.9.1 | \$,MILLIONS | | | |
| CD=CDCER X (1 X DF)XX(CDEXP) X CF | | | | 27.076 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 5.593 | | | |
| EORM =1 / M | | | | 2.000 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 1.000 | | | |
| CTFU=(CLRM / E)X(1+EORM X Z1+0.5)XX(E) -0.5XX(E)) | | | | 11.186 | | | |
| CTB =(1(CLRM/E)X(1+EORM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | |) / Z3 | | 0.0 | |
| CIPS=CTB*24/22 | | | | 0.0 | | | |
| CRC1 =CTB X R | | | | 0.0 | | | |
| PRE-106 CRC1 =CRC1 X Z6 | | | | 0.0 | | | |
| POST-106 CRL1 =CRL1 X (1.0-Z6) | | | | 0.0 | | | |
| COEM =OEM OR CTB*25/22/ENYR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND UEM WERE | | | | 0.633000 | 0.172000 | 0.0 | |

ROCKWELL SPS CK-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.9.1.42 P.T. BUS CONTROL UNIT

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|------------|----------------|-----------|--------------------|----------|-----|-----|
| T= | 170.000000 | TF= | 1.000000 | CDCER= | 0.119340 | | |
| M= | 5.000000 | UEM= | 0.0 | CDEXP= | 0.879000 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.080730 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | C1EXP= | 0.557000 | | |
| R= | 0.0 | Z3= | 0.0 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 60.000000 | Z5= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | SUM TO 1.1.9.1 | | \$,MILLIONS | | | |
| CU=CDCER X (T X DF)XX(CDEXP) X CF | | | | 10.898 | | | |
| CLRM=CICER X (M)XX(C1EXP) X CF X TF | | | | 0.198 | | | |
| URM =T / M | | | | 34.000 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 1.000 | | | |
| CTFU=(CLRM / E)X((URM X Z1+0.5)XX(E) -0.5XX(E)) | | | | 6.727 | | | |
| CTB =((CLRM/E)X((URM X Z3 + 0.5)XX(E) -0.5XX(E)) | | 1 / Z3 | | 0.0 | | | |
| C1PS=CTR*Z4/Z2 | | | | 0.0 | | | |
| CRC1 =CTB X R | | | | 0.0 | | | |
| PRE-IDC CRC1 =CRC1 X Z6 | | | | 0.0 | | | |
| POST-IDC CRC1 =CRC1 X (1.0-Z6) | | | | 0.0 | | | |
| CUEM =UEM OR C1E*Z5/Z2/ENYR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND UEM WERE | | | | 0.102000 | 0.069000 | 0.0 | |

ROCKWELL SPS CX-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.9.1.43 P.T. - MICROPROCESSORS - IMS/COM

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|---|------------|------|----------------|--------------------|----------|-----|-----|
| T= | 150.000000 | TF= | 1.000000 | CDCER= | 0.119340 | | |
| M= | 5.000000 | UEM= | 0.0 | CDEXP= | 0.879000 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.080730 | | |
| Phi= | 1.000000 | Z2= | 60.000000 | CIEXP= | 0.557000 | | |
| R= | 0.0 | Z3= | 0.0 | RYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 60.000000 | Z5= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | RG | SUM TO 1.1.9.1 | 9, MILLIONS | | | |
| CU=CDCER X (1 X DF)XX(CDEXP) X CF | | | | 9.763 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 0.198 | | | |
| FORM = T / M | | | | 30.000 | | | |
| E =1.0 + LOG(Phi) / LOG(2.0) | | | | 1.000 | | | |
| CTFU=(CLRM / E)X((FORM X Z1+0.5)XX(E) -0.5XX(E)) | | | | 5.936 | | | |
| CTB =((CLRM/E)X((FORM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | |) / Z3 | | | |
| CIPS=CIR*24/22 | | | | 0.0 | | | |
| CRC1 =CTB X R | | | | 0.0 | | | |
| PRE-IUC CRC1 =CRC1 X Z6 | | | | 0.0 | | | |
| POST-IUC LRC1 =CRC1 X (1.0-Z6) | | | | 0.0 | | | |
| COEM =UEM UR CTB*25/22/ENR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND UEM WERE | | | | 0.102000 | 0.069000 | 0.0 | |
| 0 | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.9.1.44 P.T. - REMOTE ACQ & CONTROL - IMS/COM

INPUT PARAMETERS

INPUT COEFFICIENTS

| | | | | | |
|------|------------|------|-----------|--------|----------|
| T= | 140.000000 | TF= | 1.000000 | CDCER= | 0.119340 |
| M= | 5.000000 | LEM= | 0.0 | CDEXP= | 0.879000 |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.080730 |
| PHI= | 1.000000 | Z2= | 60.000000 | C1EXP= | 0.557000 |
| R= | 0.0 | Z3= | 0.0 | BYEAR= | 1979 |
| DF= | 0.100000 | Z4= | 60.000000 | Z5= | 0.0 |
| | | | | Z6= | 0.0 |

CALCULATED VALUES

AL

SUM TO 1.1.9.1

\$, MILLIONS

CD=CDCER X (1 X DF)XX(CDEXP) X CF

1.588

CLRM=CICER X (M)XX(C1EXP) X CF X TF

0.198

ORM = T / M

38.000

E = 1.0 + LOG(PHI) / LOG(2.0)

1.000

CTFU=(CLRM / E)X(ORM X Z1+0.5)X(E) -0.5X(E)

7.519

CTB =(1CLRM/E)X((ORM X Z3 + 0.5)X(E) -0.5X(E))

1 / 23

0.0

CIPS=CTB*Z4/Z2

0.0

CRC1 = CTB X R

0.0

PRE-IUC CRC1 =CRC1 X Z6

0.0

POST-IUC LCL1 =CRC1 X (1.0-Z6)

0.0

CUM = O&M UR LIB*Z5/Z2/ENR

0.0

COMMENTS

1977 DATA ENTERED FOR CDCER, CICER, AND O&M WERE

0.102000

0.069000

0.0

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.9.1.45 P.T. - SUBMULTIPLEXER - INS/CDI

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|------------|------|----------------|--------------------|----------|-----|-----|
| T= | 3300.00000 | TF= | 1.000000 | CDCER= | 0.119340 | | |
| M= | 3.000000 | UEM= | 0.0 | CDEXP= | 0.879000 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.080730 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 0.557000 | | |
| R= | 0.0 | Z3= | 0.0 | BYEAR= | 1979 | | |
| DF= | 0.020000 | Z4= | 60.000000 | Z5= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | AG | SUM TO 1.1.9.1 | 8, MILLIONS | | | |
| CD=CDCER X (T X DF)XX(CDEXP) X CF | | | | 4.744 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 0.149 | | | |
| ERM =T / M | | | | 1100.000 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 1.000 | | | |
| CTFU=(CLRM / E)X((ERM X Z1+0.5)XX(E) -0.5XX(E)) | | | | 163.751 | | | |
| CTB =((CLRM/E)X((ERM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | |) / Z3 | | 0.0 | |
| CIPS=CTB*Z4/Z2 | | | | 0.0 | | | |
| CRCI =CTB X R | | | | 0.0 | | | |
| PRE-IOC CRCI =CRCI X Z6 | | | | 0.0 | | | |
| POST-IOC CRCI =CRCI X (1.0-Z6) | | | | 0.0 | | | |
| COEN =UEM OR CTH*Z5/Z2/ENR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND UEM WERE | | | | 0.102000 | 0.009000 | 0.0 | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.9.1.46 P.T. - INSTRUMENTATION - INS/COM

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|---|------------|------|----------------|--------------------|----------|-----|-----|
| T= | 10000.0600 | TF= | 1.000000 | CDCER= | 0.000117 | | |
| M= | 0.074100 | UEM= | 0.0 | CDEXP= | 1.000000 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.000468 | | |
| Phi= | 1.000000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.0 | Z3= | 0.0 | RYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 60.000000 | Z5= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | KG | SUM TU 1.1.9.1 | S, MILLIONS | | | |
| CU=CDCER X (1 X DF)XX(CDEXP) X CF | | | | 1.170 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 0.000 | | | |
| EORM =T / M | | | | 134952.687 | | | |
| E =1.0 + LOG(Phi) / LOG(2.0) | | | | 1.000 | | | |
| CTFU=(CLRM / E)X((EORM X Z1+.5)XX(E) -0.5XX(E)) | | | | 4.680 | | | |
| CTB =((CLRM/E)X((EORM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | 1 / Z3 | 0.0 | | | |
| CIPS=CTB*Z4/Z2 | | | | 0.0 | | | |
| CRC1 =CTB X R | | | | 0.0 | | | |
| PRE-10C CRC1 =CRC1 X Z6 | | | | 0.0 | | | |
| POST-10C CRC1 =CRC1 X (1.0-Z6) | | | | 0.0 | | | |
| COEM =UEM OR CTH*Z5/Z2/EORM | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CULM, LILER, AND UEM WERE | | | | 0.000100 | 0.000400 | 0.0 | |
| M = APPROX MASS PER SENSOR | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.9.1.47 P.T. - CABLES & HARNESS - INS/CUM

INPUT PARAMETERS

INPUT COEFFICIENTS

| | | | | | |
|------|------------|------|-----------|--------|----------|
| T= | 10600.0000 | IF= | 1.000000 | CDCEr= | 0.277290 |
| M= | 225.000000 | UEM= | 0.0 | CDEXP= | 0.297000 |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.000070 |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 1.000000 |
| R= | 0.0 | Z3= | 0.0 | BYEAR= | 1979 |
| DF= | 1.000000 | Z4= | 60.000000 | Z5= | 0.0 |
| | | | | Z6= | 0.0 |

CALCULATED VALUES

AL

SUM TO 1.1.9.1

\$,MILLIONS

$CU = CDCER \times (T \times DF) \times (CUEXP) \times CF$

4.350

$CLRM = CICER \times (M) \times (CIEXP) \times CF \times IF$

0.016

$ORM = T / M$

47.111

$E = 1.0 + \text{LOG}(PHI) / \text{LOG}(2.0)$

1.000

$CIFU = (CLRM / E) \times ((ORM \times Z1 + 0.5) \times (E) - 0.5 \times (E))$

0.744

$CTB = ((CLRM / E) \times ((ORM \times Z3 + 0.5) \times (E) - 0.5 \times (E)))$

$1 / Z3$

0.0

$CIPS = CTB \times Z4 / Z2$

0.0

$CRC1 = CTB \times R$

0.0

$PHE = IUC \quad CRC1 = CRC1 \times Z6$

0.0

$POST = IUC \quad CRC1 = CRC1 \times (1.0 - Z6)$

0.0

$CUEM = UEM \text{ OR } CTB \times Z5 / Z2 / ENVR$

0.0

COMMENTS

1977 DATA ENTERED FOR CUEM, CICER, AND UEM WERE

0.237000

0.000060

0.1

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.9.1.48 P.T. TRACKS AND ACCESSWAYS FOR MW ANT

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|------------|------|----------------|--------------------|--------------|-----|-----|
| T= | 12000.0000 | TF= | 1.000000 | CDCER= | 0.026910 | | |
| M= | 1000.00000 | UEM= | 0.0 | CDFXP= | 0.800000 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.000056 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.0 | Z3= | 0.0 | BYEAR= | 1979 | | |
| DF= | 0.500000 | Z4= | 60.000000 | Z5= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | KG | SUM TO 1.1.9.1 | | \$, MILLIONS | | |
| CD=CDCER X (T X DF)XX(CIEXP) X CF | | | | | 28.342 | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | | 0.059 | | |
| WRM = T / M | | | | | 12.000 | | |
| E = 1.0 + LOG(PHI) / LOG(2.0) | | | | | 1.000 | | |
| CTB=(CLRM / E)X((WRM X Z1+.5)XX(E) -0.5XX(E)) | | | | | 0.702 | | |
| CTA =((CLRM/E)X((WRM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | | 1 / Z3 | 0.0 | | |
| CIPS=CTB*Z4/Z2 | | | | | 0.0 | | |
| CRCI =CTB X R | | | | | 0.0 | | |
| PRE-IOC CRCI =CRCI X Z6 | | | | | 0.0 | | |
| POST-IOC CRCI =CRCI X (1.0-Z6) | | | | | 0.0 | | |
| COEM =UEM OR CTB*Z5/Z2/ENVR | | | | | 0.0 | | |

COMMENTS

1977 DATA ENTERED FOR CDCER, CICER, AND UEM WERE 0.023000 0.000050 0.0
MEMBERS AT ANTENNA FOR INSTALLATION, C/O, & VERIFICATION
OF 5250 POWER MODULES

ROCKWELL SPS LR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.9.1.49 P.T. ANT. MW LIFTS - INSTALL & C/O EQUIP.

INPUT PARAMETERS

INPUT COEFFICIENTS

| | | | | | |
|------|------------|------|-----------|--------|----------|
| T= | 15000.0000 | TF= | 1.000000 | CUCER= | 0.182520 |
| M= | 1000.00000 | UEM= | 0.0 | CDEXP= | 0.511000 |
| CF= | 1.500000 | Z1= | 1.000000 | CICER= | 0.118170 |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 0.355000 |
| R= | 0.0 | Z3= | 0.0 | BYEAR= | 1979 |
| DF= | 1.000000 | Z4= | 60.000000 | Z5= | 0.0 |
| | | | | Z6= | 0.0 |

CALCULATED VALUES

KG

SUM TO 1.1.9.1

\$, MILLIONS

$$CU = CDCER \times (1 \times DF) \times (CDEXP) \times CF$$

37.272

$$CLRM = CICER \times (M) \times (CIEXP) \times CF \times TF$$

2.059

$$WRM = T / M$$

15.000

$$E = 1.0 + \text{LOG}(PHI) / \text{LOG}(2.0)$$

1.000

$$CTFU = (CLRM / E) \times (WRM \times Z1 + 0.5) \times (E) - 0.5 \times (E)$$

30.881

$$CIB = ((CLRM / E) \times (WRM \times Z3 + 0.5) \times (E) - 0.5 \times (E))$$

1 / Z3

0.0

$$CIPS = CTFB \times Z4 / Z2$$

0.0

$$CRC1 = CTFB \times R$$

0.0

$$\text{PRE-IOC } CRC1 = CRC1 \times Z6$$

0.0

$$\text{POST-IOC } CRC1 = CRC1 \times (1.0 - Z6)$$

0.0

$$CUEM = UEM \text{ OR } CTFB \times Z5 / Z2 / \text{ENYR}$$

0.0

COMMENTS

1977 DATA ENTERED FOR CDCER, CICER, AND UEM WERE 0.156000 0.101000 0.0
CONVEYORS, POSITIONING STRUCTURES, INSTALLATION AND C/O EQUIPMENT TO
SUPPORT ANTENNA POWER MODULE ASSEMBLY

ROCKWELL SPS LP-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.9.2.1 PRECURSOR STS TRANSPORTATION

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|---|------------|--------|-----------|--------------------|-----------|-------------|-----|
| T= | 119.000000 | IF= | 1.000000 | CDCER= | 0.0 | | |
| M= | 1.000000 | DEM= | 0.0 | CDEXP= | 0.0 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 27.000076 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.0 | Z3= | 0.0 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 60.000000 | Z5= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | FLIGHT | | SUM TO 1.1.9.2 | | \$ MILLIONS | |
| CU=CDLER X (T X DF)XX(CDEXP) X CF | | | | | | 0.0 | |
| CLRM=CICER X (M)XX(CIEXP) X CF X T | | | | | | 27.000 | |
| ORM =T / M | | | | | | 119.000 | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | | | 1.000 | |
| CIFU=(CLRM / E)X(ORM X Z1+0.5)XX(E) -0.5XX(E) | | | | | | 3213.010 | |
| CTB =((CLRM/E)X(ORM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | |) / Z3 | | 0.0 | |
| CIPS=CTB*Z4/Z2 | | | | | | 0.0 | |
| CRCI =CTB X R | | | | | | 0.0 | |
| PRE-IDC CRCI =CRCI X Z6 | | | | | | 0.0 | |
| POST-IDC (RCI =CRCI X (1.0-Z6) | | | | | | 0.0 | |
| CUEM =DEM OR CIP*Z5/Z2/ENR | | | | | | 0.0 | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDLER, CICER, AND DEM WERE 0.0 23.076996 0.0 | | | | | | | |
| 927 MILLION PER STS RT FLIGHT TO SUPPORT PRECURSOR ACTIVITY(79 DOLLARS) | | | | | | | |
| INCLUDING VEHICLES. 6 PERSONNEL FLIGHTS & 113 CARGO FLIGHTS. | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.9.2.2 PRECURSOR CONSTRUCTION CREW

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|---|-----------|------|----------------|--------------------|----------|-----|-----|
| I= | 90.000000 | TF= | 1.000000 | CDCER= | 0.0 | | |
| M= | 90.000000 | UGM= | 0.0 | CDEXP= | 0.0 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.073008 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.0 | Z3= | 0.0 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 60.000000 | Z5= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | CREW | SUM TO 1.1.9.2 | \$, MILLIONS | | | |
| CU=CDCER X (I X DF) X (CDEXP) X CF | | | | 0.0 | | | |
| CLRM=CICER X (M) X (CIEXP) X CF X TF | | | | 6.571 | | | |
| E = T / M | | | | 1.000 | | | |
| E = 1.0 + LOG(PHI) / LOG(2.0) | | | | 1.000 | | | |
| CIFU=(CLRM / E) X ((1 + RM X Z1 + 0.5) X (E) - 0.5 X (E)) | | | | 6.571 | | | |
| CTB = ((CLRM / E) X ((1 + RM X Z3 + 0.5) X (E) - 0.5 X (E))) | | | 1 / Z3 | 0.0 | | | |
| CIPS=CTB X Z4 / Z2 | | | | 0.0 | | | |
| CRC1 = CTB X R | | | | 0.0 | | | |
| PRE-10C CRC1 = CRC1 X Z6 | | | | 0.0 | | | |
| POST-10C CRC1 = CRC1 X (1.0 - Z6) | | | | 0.0 | | | |
| COLM = UGM OR CIB = Z5 / Z2 / ENR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND UGM WERE 0.0 0.062400 0.0 | | | | | | | |
| AVERAGE PRELUNSR CREW OF 90 MEN DURING 12 MONTH LEO CONSTRUCTION | | | | | | | |
| ACTIVITY | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.9.2.3 PRECURSOR GEO TEST ACTIVITY

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|------------------|-----------|------|-----------|--------------------|----------|-----|-----|
| T= | 20.000000 | TF= | 1.000000 | CDCER= | 0.0 | | |
| M= | 20.000000 | UEM= | 0.0 | COEXP= | 0.0 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.029999 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.0 | Z3= | 0.0 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 60.000000 | Z5= | 0.0 | Z6= | 0.0 |

CALCULATED VALUES GRD.CREN SUM TO 1.1.9.2 \$, MILLIONS

CU=CDCER X (T X DF)XX(COEXP) X CF 0.0

CLRM=CICER X (M)XX(CIEXP) X CF X TF 0.600

$\theta RM = T / M$ 1.000

$E = 1.0 + LOG(PHI) / LOG(2.0)$ 1.000

CTFU=(CLRM / E)X((θRM X Z1+0.5)XX(E) -0.5XX(E)) 0.600

CTB =((CLRM/E)X((θRM X Z3 + 0.5)XX(E) -0.5XX(E))) / Z3 0.0

CIPS=CTB*Z4/Z2 0.0

CRC1 =CTB X R 0.0

PRE-10C CRC1 =CRC1 X Z6 0.0

POST-10C CRC1 =CRC1 X (1.0-Z6) 0.0

CUEN =OEM OR CTB*Z5/Z2/ENR 0.0

COMMENTS

1977 DATA ENTERED FOR CDCER, CICER, AND OEM WERE 0.0 0.025640 0.0
MANPOWER REQUIREMENTS FOR AVERAGE 6 MONTH PRECURSOR GROUND TEST AND
OPERATIONS ACTIVITY WITH PRECURSOR AT GEO.

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.1.9.2.4 PRECURSOR PROPELLANT

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|---|----------|------|----------------|--------------------|----------|-----|-----|
| T= | 1.000000 | TF= | 1.000000 | CDCER= | 0.0 | | |
| M= | 1.000000 | UEM= | 0.0 | COEXP= | 0.0 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 1.010880 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.0 | Z3= | 0.0 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 60.000000 | Z5= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | KG | SUM TO 1.1.9.2 | \$, MILLIONS | | | |
| CD=CDCER X (T X DF)XX(COEXP) X CF | | | | 0.0 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 1.011 | | | |
| ORM =T / M | | | | 1.000 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 1.000 | | | |
| CTFU=(CLRM / E)X(ORM X Z1+0.5)XX(E) -0.5XX(E) | | | | 1.011 | | | |
| CTB =(CLRM/E)X(ORM X Z3 + 0.5)XX(E) -0.5XX(E) | | | |) / Z3 | | | |
| CIPS=CTM*Z4/Z2 | | | | 0.0 | | | |
| CRC1 =CTB X R | | | | 0.0 | | | |
| PRE-IDC CRC1 =CRC1 X Z6 | | | | 0.0 | | | |
| POST-IDC CRC1 =CRC1 X (1.0-Z6) | | | | 0.0 | | | |
| COEM =UEM OR CTB*Z5/Z2/ENVR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND UEM WERE 0.0 0.864000 0.0 | | | | | | | |
| OPERATIONS AND TEST PROPELLANT (81/KG-1977)=81.17/KG AT 864000 KG | | | | | | | |
| PRECURSOR REQUIREMENT. | | | | | | | |

1.1.9.3 GROUND RECEIVING FACILITY

This element covers a ground receiving facility for microwave power reception during test and operational phases of the proof-of-concept/test article program.

Figure 1.1-11 illustrates a typical concept for the ground receiving facility. It is about the size of one-half the area of a football field. Rectenna panels are comprised of dipoles, appropriately spaced, on a ground plane of wire mesh builder's "cloth."

An engineering estimate is presented in Table 1.1.9.3 considering that DDT&E for this facility is included in the research and development program.

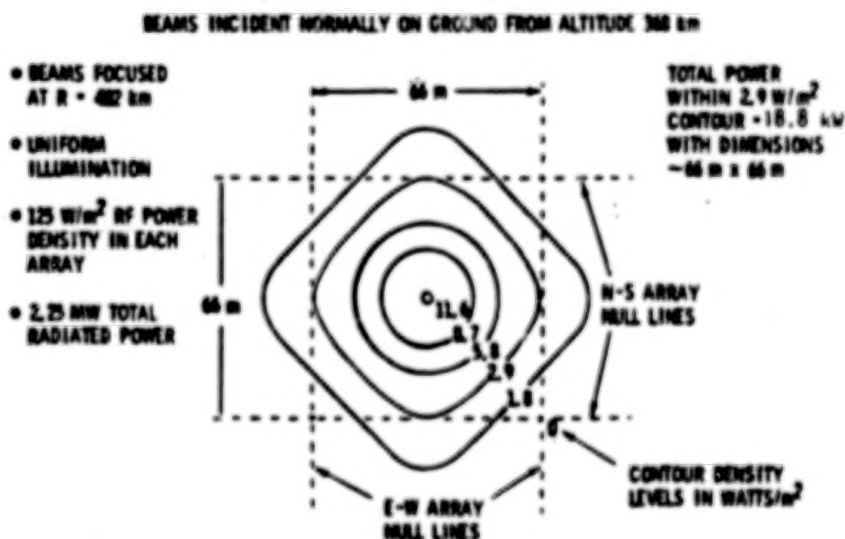
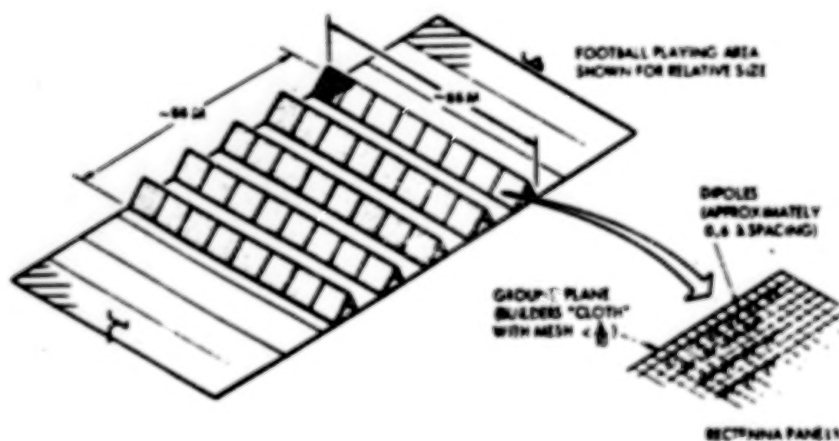


Figure 1.1-11. Ground Receiving Facility

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ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980

TABLE 1.1.9.3 PRECURSOR GROUND RECEIVING FACILITY

INPUT PARAMETERS

| | | | |
|------|----------|------|-----------|
| T= | 1.000000 | TF= | 1.000000 |
| M= | 1.000000 | LEM= | 0.0 |
| CF= | 1.000000 | Z1= | 1.000000 |
| PHI= | 1.000000 | Z2= | 60.000000 |
| R= | 0.0 | Z3= | 0.0 |
| DF= | 1.000000 | Z4= | 60.000000 |

INPUT COEFFICIENTS

| | |
|--------|----------|
| CDCER= | 0.0 |
| CDEXP= | 0.0 |
| CICER= | 4.999995 |
| CIEXP= | 1.000000 |
| BYEAR= | 1979 |
| Z5= | 0.0 |
| Z6= | 0.0 |

CALCULATED VALUES

FACILITY

SUM TO 1.1.9

\$, MILLIONS

$$CD = CDCER \times (T \times DF) \times (CDEXP) \times CF$$

0.0

$$CLRM = CICER \times (M) \times (CIEXP) \times CF \times TF$$

5.000

$$\theta_{RM} = T / M$$

1.000

$$E = 1.0 + \log(PHI) / \log(2.0)$$

1.000

$$CTFU = (CLRM / E) \times ((\theta_{RM} \times Z1 + 0.5) \times (E) - 0.5 \times (E))$$

5.000

$$CTH = ((CLRM / E) \times ((\theta_{RM} \times Z3 + 0.5) \times (E) - 0.5 \times (E)))$$

1 / Z3

0.0

$$CIPS = CTH \times Z4 / Z2$$

0.0

$$CRC1 = CTH \times R$$

0.0

$$PRE-IOC \quad CRL1 = CRC1 \times Z6$$

0.0

$$POST-IOC \quad CRC1 = CRC1 \times (1.0 - Z6)$$

0.0

$$CGEM = CGEM \text{ OR } CTH \times Z5 / Z2 / ENVR$$

0.0

COMMENTS

1977 DATA ENTERED FOR CDCER, CICER, AND CGEM WERE 0.0 4.273500 0.0
ENGINEERING ESTIMATE. DDTE FOR PRECURSOR RECTENNA INCLUDED IN GRED
PROGRAM

B-220

1.2 SPACE CONSTRUCTION AND SUPPORT

This element includes all hardware and activities/operations required to fabricate, assemble, checkout, operate and maintain the satellite system and supporting elements of the space segment. Included are logistic support facilities and operations, construction base and operations, and operations/maintenance requirements.

The updated Rockwell SPS Reference Configuration—1980 is used as the baseline concept for development of cost and programmatic information. As indicated in previous sections, four other concepts were studied and defined for purposes of establishing cost estimates including those of required construction and support equipment unique to these particular designs. A summary of cost estimates for these configurations is presented in Table 1.2-1.

Table 1.2-1. Investment Costs for Space Construction and Support Equipment

| SPS SATELLITE CONCEPT (1980) | 1979 DOLLARS $\times 10^6$ | | | |
|--|----------------------------|--------------------------------|----------------------|-----------|
| | SPS OPTION QUANTITY | INVESTMENT PER SATELLITE | RCI/O&M PER SAT. YR. | |
| | | | PRE-IOC | POST-IOC |
| ROCKWELL SPS CR-2 REFERENCE CONFIGURATION (3-TROUGH/PLANAR/KLYSTRON) SATELLITE MASS (DRY)— 25.306×10^6 kg | 60 | \$209.874 | \$ 8.044 | \$ 30.762 |
| SPS CR-2 MAGNETRON CONFIGURATION (3-TROUGH/PLANAR) SATELLITE MASS (DRY)— 21.44×10^6 kg | 54 | 225.611 | 10.453 | 31.170 |
| DUAL END-MOUNTED ANTENNA CR-2 SPS (3-TROUGH/PLANAR/SOLID STATE) SATELLITE MASS (DRY)— 31.978×10^6 kg | 58 | 214.741 | 8.325 | 31.098 |
| SOLID-STATE SANDWICH CONFIGURATION CR-5 (DUAL ANTENNA AND REFLECTORS—GaAs) SATELLITE MASS (DRY)— 16.423×10^6 kg | 125 | 107.426 | 6.080 | 25.523 |
| SOLID-STATE SANDWICH CONFIGURATION CR-5 (DUAL ANTENNA AND REFLECTORS—MBG) SATELLITE MASS (DRY)— 13.109×10^6 kg | 98 | 137.024 | 7.120 | 26.503 |

An overall scenario of construction sequences leading to the first operational SPS satellite is shown in Figure 1.2-1. The initial step is to establish a LEO Station for the fabrication of a construction fixture to build the SCB. Crew and materials would be transported to LEO by the STS HLLV with liquid rocket boosters. Cost estimates on the STS growth vehicle for personnel and a derivative vehicle for cargo are presented in Section 1.3.3. Shuttle external tanks from the use of these vehicles would be delivered to LEO and combined to form a construction fixture for the SCB.

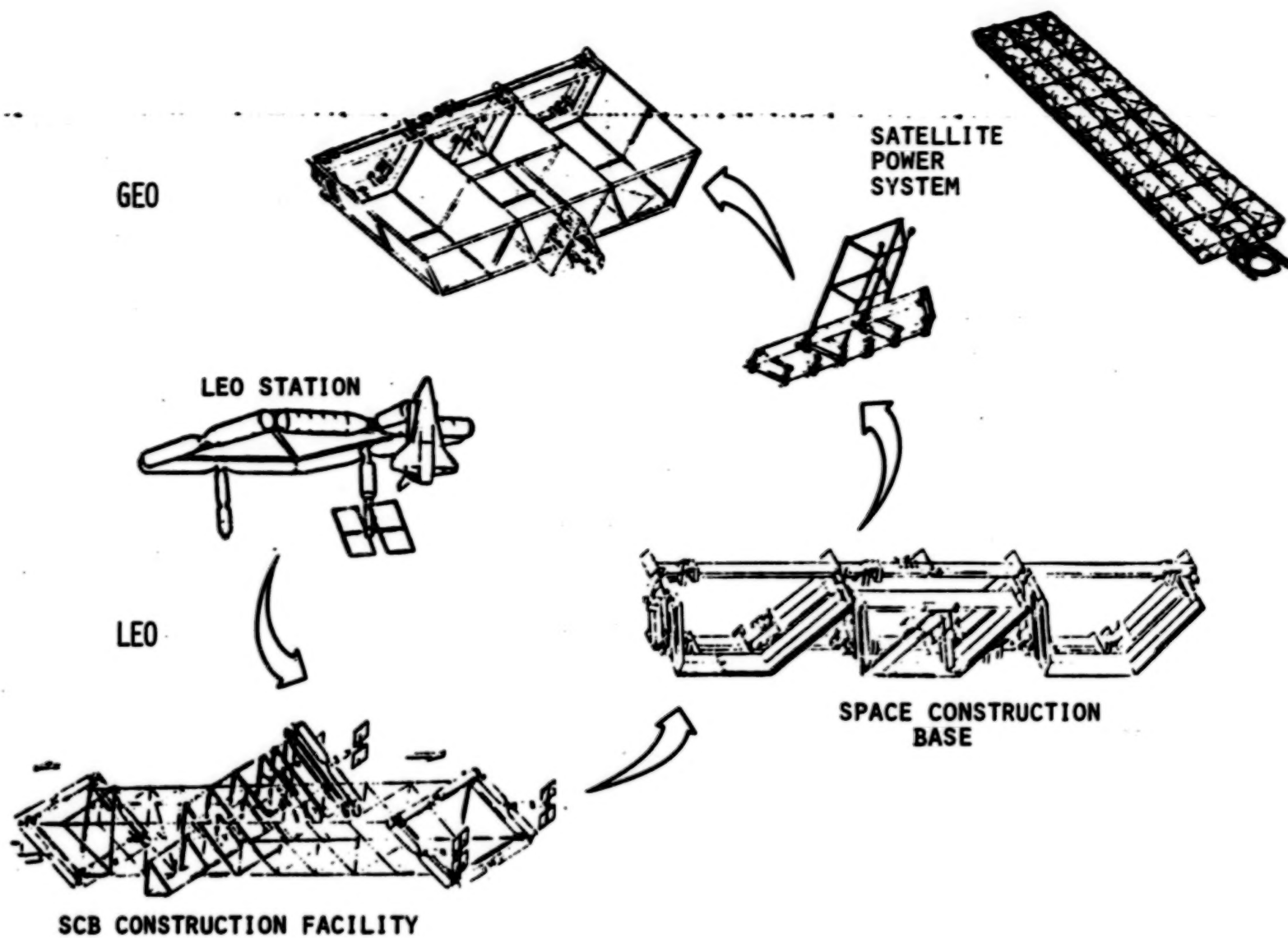


Figure 1.2-1. Satellite Construction

After SCB construction, one of its first functional requirements would be to fabricate EOTV's that will serve as the vehicle for LEO-GEO cargo transfer and the movement of this base to its operational location in GEO. Once in GEO, the SCB would be outfitted for construction of a first satellite. As the SPS-HLLV is scheduled for availability when the SCB is completed, this vehicle would be used to deliver masses to LEO for EOTV and SPS satellite construction. During the 30 year satellite construction period, the SPS-HLLV will become the transportation element for delivering construction mass and personnel to LEO.

The energy conversion segment of the satellite structure is constructed by the integrated SCB in a single pass. Satellite longerons of a length sufficient to connect the triangular frames of the slip ring support structure are fabricated, followed by construction of the slip ring interface structure, and the first satellite structure frame. The SCB then proceeds to fabricate/install the remainder of the satellite structure and solar converter. Construction of the slip rings, and yoke (interface) takes place concurrently using free flying fabrication facilities to support this building process (Figure 1.2-2).

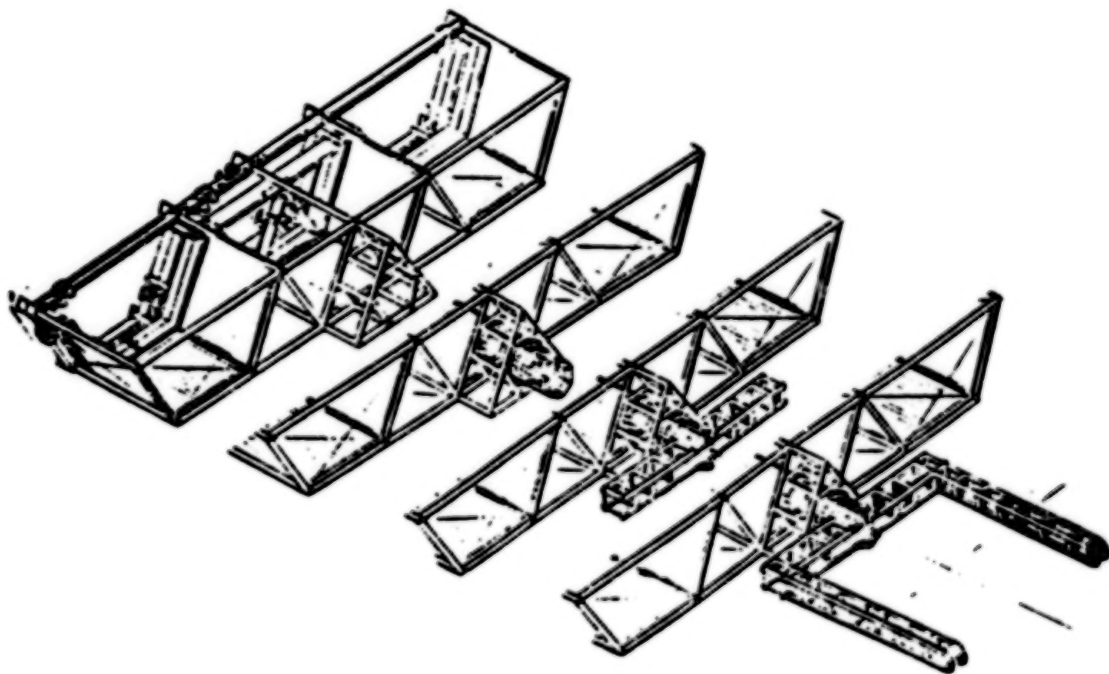


Figure 1.2-2. Antenna Supporting Structure Assembly Sequence

The following pages of this report describe facilities/equipment, and operations required for construction of space segment elements covering the elements of work, crew, and operational needs during the SPS program. Section 1.2.1 deals with construction related facilities and crew/operations; and Section 1.2.2 deals with work and crew requirements of the LEO logistics base. Operations and maintenance of the satellite including replacement capital materials/systems, after SPS-IOC, is included in Section 1.2.3.

1.2.1 CONSTRUCTION FACILITIES

This element includes the facilities, equipment, and operations required to fabricate, assemble, and checkout the satellite system. Specifically included are crew support facilities, the SCB and central control facility, fabrication and assembly equipment/facilities, cargo depots, and crew/provisions during construction.

Satellites are constructed in GEO at its designated longitudinal location. The SCB supports construction of two satellites per year during the program and serves as headquarters for operations and maintenance activities necessary to support the satellite.

The SCB is constructed of composites and consists of the fabrication fixture, construction equipment, and base support facilities. It is in the form of three troughs, corresponding to the satellite configuration and permits simultaneous construction of all troughs. Additional structural members are located in the middle trough to support fabrication of rotary joint and antenna structures. Figure 1.2-3 illustrates the construction base and shows the location of work and crew facilities.

SCB fabrication fixture assembly and support equipment, and crew/work modules are itemized in Table 1.2-2. Modules used to support crew/work activities are of various internal configurations to accommodate specific functional requirements. All modules are of the same diameter and most are of the same length, their dimensions and mass being in compliance with space transportation system constraints. Modules are located on the fab fixture along with SCB assembly and support equipment.

The Airlock Docking Module (ADM) is used to join other base modules to provide docking accommodations for other elements such as crew transport modules, consumables logistics modules (CLM) and intra-base logistics vehicles, and for transfer of personnel and equipment between different pressure environments. The Crew Habitability Module (CHM) provides stateroom and personal hygiene facilities, and support systems for 24 to 30 crew members. The Base Management Module (BMM) houses operational communications and control systems for the base. Power Modules (PM) are photovoltaic power systems (collectors, converters, conditioners, and storage) which support all base power requirements. Pressurized Storage Modules (PSM) provide an area for storage and workshop accommodations. Shielding (SHD) is provided in selected modules to protect against solar flare radiation. A Crew Support Module (CSM) provides the galley, recreational and medical facilities and support subsystems.

1.2.1.1 WORK SUPPORT FACILITIES—SCB

This element includes work facilities and equipment required for satellite fabrication, assembly, and checkout. Included are beam fabricators, manipulators, assembly jigs, installation and deployment equipment, and cargo storage depots. Excluded are the facilities related to crew support.

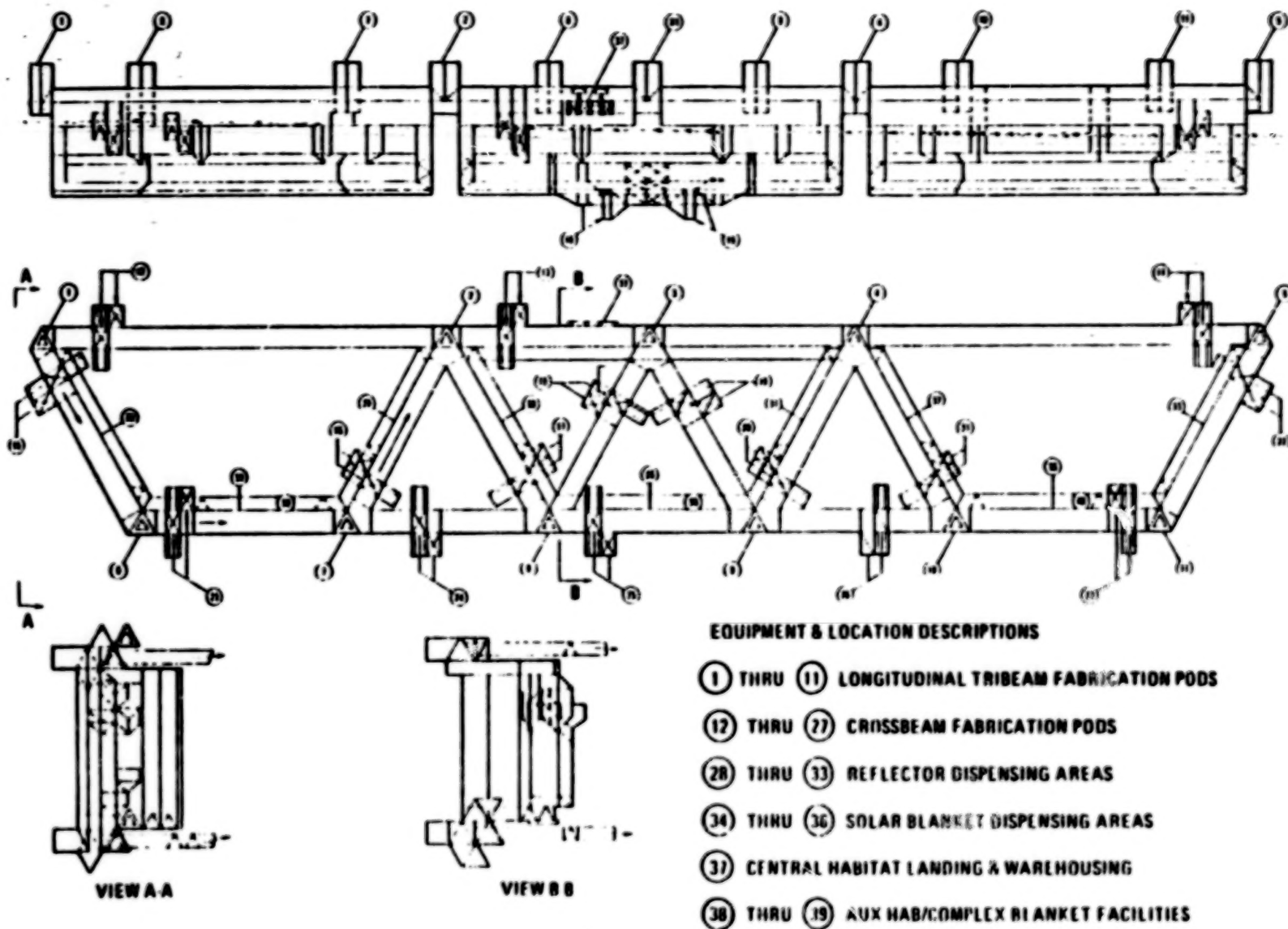


Figure 1.2-3. Satellite Construction Base (SCB)

Table 1.2-2. Construction Facilities

| SYSTEM DESCRIPTION | QUANTITY FOR CONSTRUCTION |
|--------------------------------------|---------------------------------|
| WORK SUPPORT FACILITIES (1.2.1.1) | |
| BEAM MACHINE | 198 |
| BEAM MACHINE CASSETTES | 1206 |
| CABLE ATTACHMENT MACHINES | 78 |
| REMOTE MANIPULATOR | 55 |
| SOLAR BLANKET DISPENSER MACHINE | 78 |
| SOLAR BLANKET CASSETTES | 1560 |
| REFLECTOR DISPENSER MACHINES | 6 |
| REFLECTOR CASSETTES | 120 |
| CABLE/CATENARY DISPENSERS | 84 |
| ANTENNA PANEL INSTALLATION EQUIPMENT | 1 |
| GANTRY/CRANES | 12 |
| CARGO STORAGE DEPOT | 4 |
| SCB FABRICATION FIXTURE | 1 |
| AIRLOCK DOCKING MODULE | 17 |
| BASE MANAGEMENT MODULE | 4 |
| POWER MODULE | 4 |
| PRESSURIZED STORAGE MODULE | 4 |
| CREW SUPPORT FACILITIES (1.2.1.2) | |
| AIRLOCK DOCKING MODULE | 5 |
| CREW HABITABILITY MODULE | 17 |
| CONSUMABLES LOGISTICS MODULE | 9 |
| SHIELDING | 8 |
| CREW SUPPORT MODULE | 3 |

Modules associated with work support activities include the ADM-17 units, BMM-4 modules, PM-4 units, and PSM-4 modules. CER's used for these modules were based on Rockwell Space Station studies.

All SPS unique fabrication/orbital construction assembly and support equipment is included in this section (reference Table 1.2-2). Included are the tri-beam fabricators, cable attachment machines, solar blanket/concentrator dispensing machines, and antenna panel installation equipment. Each of these requirements were analyzed for equipment usage, replacement factors, O&M, and projected costs based on engineering estimates of design characteristics. The items of assembly and support equipment and base modules remain on the SCB as it transfers from one construction site to another.

1.2.1.2 CREW SUPPORT FACILITIES - SCB

This element includes facilities and equipment required for life support and well-being of the crew members. Included are living quarters, central control facilities, recreation facilities, and health facilities of the satellite construction base. Crew support facilities include 5 ADMs, 17 CHMs, 9 CLMs, 8 shielding and 3 CSMs.

1.2.1.3 OPERATIONS

This element includes the planning, development, and conduct of operations at the construction facility. It includes both direct and support personnel and expendable maintenance supplies for satellite assembly and checkout.

This element has been divided into the subelements of operations and consumables where an average crew of 317 persons per shift is required to man the SCB over the normal six month fabrication period. A crew rotation is scheduled for every three months. Consumables for the SCB are calculated at 3.6 kg/person/day.

1.2.1.4 COST ESTIMATES

Cost estimates for work and crew facilities, plus operations, are referenced in Table 1.2-3.

Table 1.2-3. Construction Facility Estimates

| WBS TABLE NO's | DESCRIPTION |
|------------------------------|-----------------------------|
| 1.2.1.1.1 thru 1.2.1.1.17 | Work Support Facilities—SCB |
| 1.2.1.2.1 thru 1.2.1.2.5 | Crew Support Facilities—SCB |
| 1.2.1.3.1, 1.2.1.3.2 | SCB Operations |

ROCKWELL SPS LR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.2.1.1.1 BEAM MACHINE

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|---|----------|------|----------------|--------------------|----------|-----|----------|
| TF= | 1.000000 | IF= | 1.000000 | EDGER= | 2.540000 | | |
| M= | 1.000000 | UGM= | 0.810810 | CDEXP= | 1.000000 | | |
| CF= | 1.000000 | Z1= | 198.000000 | CICER= | 0.819000 | | |
| PHI= | 0.950000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.0 | Z3= | 198.000000 | EYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 198.000000 | Z5= | 0.0 | Z6= | 1.000000 |
| CALCULATED VALUES | | SET | SUM TO 1.2.1.1 | \$, MILLIONS | | | |
| CU=CDGER X (T X DF)XX(CDEXP) X CF | | | | 2.340 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 0.819 | | | |
| ORM = T / M | | | | 1.000 | | | |
| E = 1.0 + LOG(PHI) / LOG(2.0) | | | | 0.926 | | | |
| LTFU=(CLRM / E)X(ORM X Z1+.5)XX(E) -0.5XX(E) | | | | 118.220 | | | |
| CTB =(CLRM/E)X(ORM X Z3 + 0.5)XX(E) -0.5XX(E) | | | | 1 / 23 | | | |
| LIPS=CTB*Z4/Z2 | | | | 0.597 | | | |
| LRCI =CTB X R | | | | 1.970 | | | |
| PRE-10C LRCI =LRCI X .6 | | | | 0.0 | | | |
| POST-10C LRCI =LRCI X (1.0-.6) | | | | 0.0 | | | |
| CUGM =UGM OR CTB*Z5/Z2/EYR | | | | 0.0 | | | |
| | | | | 0.811 | | | |

COMMENTS

1977 DATA ENTERED FOR CDGER, CICER, AND UGM WERE 2.000000 0.700000 0.693000
2 METER BEAM MACHINES. COSTS BASED ON NAS-15310. 30 YEAR LIFE
ESTABLISHED WITH MAINTENANCE AGAINST A 3 YEAR FULL TIME SERVICE/DUTY
CYCLE

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ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.2.1.1.2 BEAM MACHINE CASSETTES SET

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|---|----------|------|----------------|--------------------|----------|-----|----------|
| T= | 1.000000 | TF= | 1.000000 | CDCER= | 0.936000 | | |
| M= | 1.000000 | UGM= | 0.115704 | CDEXP= | 1.000000 | | |
| CF= | 1.000000 | Z1= | 1206.00000 | CICER= | 0.009594 | | |
| PHI= | 0.950000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.000670 | Z3= | 3618.00000 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 2412.00000 | Z5= | 0.0 | Z6= | 1.000000 |
| CALCULATED VALUES | | SET | SUM TO 1.2.1.1 | \$,MILLIONS | | | |
| CU=CDCER X (T X DF)XX(CDEXP) X CF | | | | 0.936 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 0.010 | | | |
| ERM =T / M | | | | 1.000 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 0.926 | | | |
| CIFU=(CLRM / E)X((ERM X Z1+0.5)XX(E) -0.5XX(E)) | | | | 7.389 | | | |
| CTB =((CLRM/E)X((ERM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | |) / Z3 0.006 | | | |
| CIPS=CTB*Z4/Z2 | | | | 0.227 | | | |
| CRC1 =CTB X R | | | | 0.004 | | | |
| PRE-10C CRC1 =CRC1 X Z6 | | | | 0.004 | | | |
| POST-10C CRC1 =CRC1 X (1.0-Z6) | | | | 0.0 | | | |
| UGM =UGM OR CTB*Z5/Z2/ENYH | | | | 0.116 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND UGM WERE 0.800000 0.000200 0.098892 | | | | | | | |
| SERVICE/DUTY CYCLE OF 3 YEARS WITH REPLACEMENT EVERY 15 YEARS. | | | | | | | |
| 1206 FOR HCI. Z4=1206 SCB REQUIREMENT PLUS 1206 ROTATION | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.2.1.1.3 CABLE ATTACHMENT MACHINE

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|---|----------|------|----------------|--------------------|----------|-------|----------|
| T= | 1.000000 | TF= | 1.000000 | CDCER= | 5.031000 | | |
| M= | 1.000000 | UEM= | 0.228150 | CDEXP= | 1.000000 | | |
| CF= | 1.000000 | Z1= | 78.000000 | CICER= | 0.585000 | | |
| PHI= | 0.950000 | Z2= | 60.000000 | CIFXP= | 1.000000 | | |
| R= | 0.0 | Z3= | 78.000000 | RYEAR= | 1979 | | |
| UF= | 1.000000 | Z4= | 78.000000 | Z5= | 0.0 | Z6= | 1.000000 |
| CALCULATED VALUES | | SET | SUM TO 1.2.1.1 | \$, MILLIONS | | | |
| CD=CDCER X (1 X UF)XX(CDEXP) X CF | | | | 5.031 | | | |
| CLRM=CICER X (M)XX(CIFXP) X CF X TF | | | | 0.585 | | | |
| WRM =T / M | | | | 1.000 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 0.926 | | | |
| CTFU=(CLRM / E)X((WRM X Z1)+.5)XX(E) -0.5XX(E) | | | | 35.576 | | | |
| CTB =((CLRM/E)X((WRM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | | 1 / Z3 | | 0.456 | |
| CIPS=CTB*24/72 | | | | 0.593 | | | |
| CRC1 =CTB X R | | | | 0.0 | | | |
| PRE-IOC CRC1 =CRC1 X Z6 | | | | 0.0 | | | |
| POST-IOC CRC1 =CRC1 X (1.0-Z6) | | | | 0.0 | | | |
| OQM =OQM OR CTB*25/22/ENYR | | | | 0.228 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND OQM WERE 4.300000 0.500000 0.195000 | | | | | | | |
| SERVICE/DUTY CYCLE OF 3 YEARS WITH 30 YEAR EQUIPMENT LIFE TIME | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.2.1.1.4 REMOTE MANIPULATOR

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|---|----------|------|----------------|--------------------|----------|-----|----------|
| T= | 1.000000 | TF= | 1.000000 | CDCER= | 8.049601 | | |
| M= | 1.000000 | UEM= | 0.360250 | CDEXP= | 1.000000 | | |
| CF= | 1.000000 | Z1= | 55.000000 | CICER= | 1.310049 | | |
| PHI= | 0.980000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.030600 | Z3= | 110.000000 | BYEAR= | 1979 | | |
| DF= | 0.500000 | Z4= | 55.000000 | Z5= | 0.0 | Z6= | 1.000000 |
| CALCULATED VALUES | | SET | SUM TO 1.2.1.1 | \$,MILLIONS | | | |
| CU=CDCER X (T X DF)XX(CDEXP) X CF | | | | 4.025 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 1.310 | | | |
| E = T / M | | | | 1.000 | | | |
| E = 1.0 + LOG(PHI) / LOG(2.0) | | | | 0.971 | | | |
| CTFU=(CLRM / E)X((E X Z1 + 0.5)XX(E) - 0.5XX(E)) | | | | 65.929 | | | |
| CTB = ((CLRM/E)X((E X Z3 + 0.5)XX(E) - 0.5XX(E))) / Z3 | | | | 1.175 | | | |
| CIPS=CTB*Z4/Z2 | | | | 1.078 | | | |
| CRC1 = CTB X R | | | | 0.036 | | | |
| PRE-IUC CRC1 =CRC1 X Z6 | | | | 0.036 | | | |
| POST-IUC CRC1 =CRC1 X (1.0-Z6) | | | | 0.0 | | | |
| UEM =UEM OR CTB*Z5/Z2/ENYR | | | | 0.360 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND UEM WERE 6.880000 1.119700 0.307906 | | | | | | | |
| SERVICE/DUTY CYCLE OF 7.5 YEARS WITH LIFE AT 15 YEARS FOR RC1. | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.2.1.1.5 BLANKET DISPENSER MACHINE

INPUT PARAMETERS

INPUT COEFFICIENTS

| | | | | | |
|------|----------|------|-----------|--------|----------|
| T= | 1.000000 | TF= | 1.000000 | CDCER= | 4.680000 |
| M= | 1.000000 | OEM= | 0.162520 | COEXP= | 1.000000 |
| CF= | 1.000000 | Z1= | 78.000000 | CICER= | 0.468000 |
| PHI= | 0.960000 | Z2= | 60.000000 | CIEXP= | 1.000000 |
| R= | 0.0 | Z3= | 78.000000 | BYEAR= | 1979 |
| DF= | 1.000000 | Z4= | 78.000000 | Z5= | 0.0 |
| | | | | Z6= | 1.000000 |

CALCULATED VALUES

SET

SUM TO 1.2.1.1

\$, MILLIONS

$$CU = CDCER \times (1 \times DF) \times (CIEXP) \times CF$$

4.680

$$CLRM = CICER \times (M) \times (CIEXP) \times CF \times TF$$

0.468

$$\theta RM = T / M$$

1.000

$$E = 1.0 + \log(PHI) / \log(2.0)$$

0.971

$$CTFU = (CLRM / E) \times ((\theta RM \times Z1 + 0.5) \times (E) - 0.5 \times (E))$$

33.076

$$CTB = ((CLRM / E) \times ((\theta RM \times Z3 + 0.5) \times (E) - 0.5 \times (E)))$$

1 / Z3

0.424

$$CIPS = CTR \times Z4 / Z2$$

0.551

$$CRC1 = CTB \times R$$

0.0

$$PRE-10C \quad CRC1 = CRC1 \times Z6$$

0.0

$$POST-10C \quad CRC1 = CRC1 \times (1.0 - Z6)$$

0.0

$$LOEM = OEM \text{ OR } LIB \times Z5 / Z2 / ENYR$$

0.183

COMMENTS

1977 DATA ENTERED FOR CDCER, CICER, AND OEM WERE 4.000000

0.400000

0.156000

SERVICE/DUTY CYCLE OF 2.5 YEARS WITH 30 YEAR LIFE FOR RC1

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.2.1.1.6 SOLAR BLANKET CASSETTES

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|---|----------|------|----------------|--------------------|----------|-------|----------|
| T= | 1.000000 | TF= | 1.000000 | CDCER= | 0.936000 | | |
| M= | 1.000000 | UEM= | 0.156000 | CDEXP= | 1.000000 | | |
| CF= | 1.250000 | Z1= | 1560.00000 | CICER= | 0.011700 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 1.733330 | Z3= | 6240.00000 | BYEAR= | 1979 | | |
| UF= | 1.000000 | Z4= | 3120.00000 | Z5= | 0.0 | Z6= | 1.000000 |
| CALCULATED VALUES | | SET | SUM TO 1.2.1.1 | \$, MILLIONS | | | |
| CU=CDCER X (T X UF)XX(CDEXP) X CF | | | | 1.170 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 0.015 | | | |
| THRM = T / M | | | | 1.000 | | | |
| E = 1.0 + LOG(PHI) / LOG(2.0) | | | | 1.000 | | | |
| CTFU=(CLRM / E)X((THRM X Z1+0.5)XX(E) -0.5XX(E)) | | | | 22.815 | | | |
| CTB = ((CLRM/E)X((THRM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | | 1 / Z3 | | 0.015 | |
| CIPS=CTB*Z4/Z2 | | | | 0.761 | | | |
| CRC1 =CTB X R | | | | 0.025 | | | |
| PRE-10C CRC1 =CRC1 X Z6 | | | | 0.025 | | | |
| POST-10C LCL1 =CRC1 X (1.0-Z6) | | | | 0.0 | | | |
| LUEM =UEM UK CTB*Z5/Z2/ENYR | | | | 0.156 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND UEM WERE 0.800000 0.010000 0.133333 | | | | | | | |
| SERVICE/DUTY CYCLE AT 2.5 YEARS WITH 10 YEAR LIFE. 3120 FOR RC1. | | | | | | | |
| Z4=1560 FOR SCR AND 1560 FOR ROTATION | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.2.1.1.7 REFLECTOR DISPENSER MACHINE

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|----------|------|----------------|--------------------|----------|----------|----------|
| T= | 1.000000 | TF= | 1.000000 | CDLER= | 7.020000 | | |
| M= | 1.000000 | LEM= | 0.028080 | CDEXP= | 1.000000 | | |
| CF= | 1.000000 | Z1= | 6.000000 | CICER= | 0.936000 | | |
| PHI= | 0.980070 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.0 | Z3= | 6.000000 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 6.000000 | Z5= | 0.0 | Z6= | 1.000000 |
| CALCULATED VALUES | | SET | SUM TO 1.2.1.1 | 8, MILLIONS | | | |
| CD=CDLER X (T X DF)XX(CDEXP) X CF | | | | 7.020 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 0.936 | | | |
| ORM = T / M | | | | 1.000 | | | |
| E = 1.0 + LOG(PHI) / LOG(2.0) | | | | 0.971 | | | |
| CTFU=(CLRM / E)X((ORM X Z1+0.5)XX(E) -0.5XX(E)) | | | | 5.442 | | | |
| CTB =((CLRM/E)X((ORM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | | 1 / Z3 | | 0.907 | |
| CIPS=CTB*24/22 | | | | 0.091 | | | |
| CRC1 =CTB X R | | | | 0.0 | | | |
| PRE-10C CRC1 =CRC1 X Z6 | | | | 0.0 | | | |
| POST-10C CRC1 =CRC1 X (1.0-Z6) | | | | 0.0 | | | |
| COEM =OEM UR CTB*25/22/ENVR | | | | 0.028 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND OEM WERE | | | | 6.000000 | 0.800000 | 0.024000 | |
| SERVICE/DUTY CYCLE AT 2.5 YEARS WITH 30 YEAR LIFE. | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.2.1.1.0 REFLECTOR CASSETTES

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|----------|------|----------------|--------------------|----------|--------------|----------|
| T= | 1.000000 | TF= | 1.000000 | CDCER= | 1.170000 | | |
| M= | 1.000000 | LEM= | 0.042120 | CDEXP= | 1.000000 | | |
| CF= | 1.000000 | Z1= | 120.000000 | CILER= | 0.035100 | | |
| PHI= | 0.950000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.066667 | Z3= | 360.000000 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 240.000000 | Z5= | 0.0 | Z6= | 1.000000 |
| CALCULATED VALUES | | SET | SUM TO 1.2.1.1 | | | \$, MILLIONS | |
| CU=CDCER X (T X DF)X(CDEXP) X CF | | | | | | 1.170 | |
| CLRM=CILER X (M)X(CIEXP) X CF X TF | | | | | | 0.035 | |
| FORM = T / M | | | | | | 1.000 | |
| E = 1.0 + LOG(PHI) / LOG(2.0) | | | | | | 0.926 | |
| CTBU=(CLRM / E)X((FORM X Z1+0.5)X(E) -0.5X(E)) | | | | | | 3.184 | |
| CTB = (CLRM/E)X((FORM X Z3 + 0.5)X(E) -0.5X(E)) | | | | 1 / Z3 | | 0.024 | |
| CIPS=CTB*Z4/Z2 | | | | | | 0.098 | |
| CRC1 =CTB X R | | | | | | 0.002 | |
| PRE-10C LRC1 =CRC1 X Z6 | | | | | | 0.002 | |
| POST-10C CRC1 =CRC1 X (1.0-Z6) | | | | | | 0.0 | |
| CUEM =OEM OR CTB*Z5/Z2/ENYR | | | | | | 0.042 | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CILER, AND OEM WERE | | | | 1.000000 | 0.030000 | 0.036000 | |
| SERVICE DUTY CYCLE AT 2.5 YEARS WITH 15 YEAR LIFE SPAN. 120 FOR RC1. | | | | | | | |
| Z4=120 FOR SCB AND 120 FOR ROTATION | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.2.1.1.9 CABLE/CATENARY DISPENSER MACHINES

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|---|----------|------|----------------|--------------------|----------|-----|----------|
| T= | 1.000000 | TF= | 1.000000 | CDCER= | 2.573999 | | |
| M= | 1.000000 | LSM= | 0.073710 | COEXP= | 1.000000 | | |
| CF= | 1.000000 | Z1= | 84.000000 | CICER= | 0.351000 | | |
| PHI= | 0.980000 | Z2= | 80.000000 | CIEXP= | 1.000000 | | |
| R= | 0.0 | Z3= | 84.000000 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 84.000000 | Z5= | 0.0 | Z6= | 1.000000 |
| CALCULATED VALUES | | SEE | SUM TO 1.2.1.1 | \$,MILLIONS | | | |
| CD=CDCER X (T X DF)XX(COEXP) X CF | | | | 2.574 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 0.351 | | | |
| ERM = T / M | | | | 1.000 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 0.971 | | | |
| CTFU=(CLRM / E)X((ERM X Z1+.5)XX(E) -0.5XX(E)) | | | | 26.660 | | | |
| CTB =((CLRM/E)X((ERM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | |) / Z3 0.317 | | | |
| CIPS=CTB*Z4/Z2 | | | | 0.444 | | | |
| CRC1 =CTB X R | | | | 0.0 | | | |
| PRE-10C CRC1 =CRC1 X Z6 | | | | 0.0 | | | |
| POST-10C CRC1 =CRC1 X (1.0-Z6) | | | | 0.0 | | | |
| O&M =O&M OR CTB*Z5/Z2/ENYR | | | | 0.074 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND O&M WERE 2.200000 0.300000 0.063000 | | | | | | | |
| SERVICE/DUTY CYCLE 2.5 YEARS. 30 YEAR LIFE SPAN WITH MAINTENANCE | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.2.1.1.10 ANTENNA PANEL INS. EQPT.

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|---|----------|------|----------------|--------------------|------------|---------|----------|
| T= | 1.000000 | TF= | 1.000000 | CDCER= | 702.000000 | | |
| M= | 1.000000 | UEM= | 1.170000 | CDEXP= | 1.000000 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 234.000015 | | |
| PHI= | 0.980000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.0 | Z3= | 1.000000 | BYEAR= | 1979 | | |
| DF= | 0.133333 | Z4= | 1.000000 | 25= | 0.0 | Z6= | 1.000000 |
| CALCULATED VALUES | | SET | SUM TO 1.2.1.1 | \$, MILLIONS | | | |
| C1=CDCER X (T X DF)XX(CDEXP) X CF | | | | 93.600 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 234.000 | | | |
| FORM = T / M | | | | 1.000 | | | |
| E = 1.0 + LOG(PHI) / LOG(2.0) | | | | 0.971 | | | |
| CTFU=(CLRM / E)X((FORM X Z1+0.5)XX(E) -0.5XX(E)) | | | | 234.318 | | | |
| CTB = ((CLRM/E)X((FORM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | |) / Z3 | | 234.318 | |
| CIPS=CTB*Z4/Z2 | | | | 3.905 | | | |
| CRC1 =CTB X R | | | | 0.0 | | | |
| PRE-IOC CRC1 =CRC1 X Z6 | | | | 0.0 | | | |
| POST-IOC CRC1 =CRC1 X (1.0-Z6) | | | | 0.0 | | | |
| CUEM =UEM OR CTB*Z5/Z2/ENVR | | | | 1.170 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND UEM WERE 600.000000 200.000000 1.000000 | | | | | | | |
| SERVICE/DUTY CYCLE AT 70 DAYS PER SATELLITE. LIFE OF 30 YEARS | | | | | | | |
| WITH MAINTENANCE | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.2.1.1.11 GANTRY/CranES

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|----------|------|----------------|--------------------|-----------|-----|----------|
| T= | 1.000000 | TF= | 1.000000 | CDCER= | 19.889999 | | |
| M= | 1.000000 | DEM= | 0.280800 | CDEXP= | 1.000000 | | |
| CF= | 1.000000 | Z1= | 12.000000 | CICER= | 9.360001 | | |
| PHI= | 0.950000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.0 | Z3= | 12.000000 | BYEAR= | 1979 | | |
| DF= | 0.800000 | Z4= | 12.000000 | Z5= | 0.0 | Z6= | 1.000000 |
| CALCULATED VALUES | | SET | SUM TO 1.2.1.1 | \$, MILLIONS | | | |
| CD=CDCER X (T X DF)XX(CDEXP) X CF | | | | 15.912 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 9.360 | | | |
| ORM =T / M | | | | 1.000 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 0.926 | | | |
| CTFU=(CLRM / E)X(ORM X Z1+0.5)XX(E) -0.5XX(E) | | | | 99.490 | | | |
| CTB =((CLRM/E)X(ORM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | |) / Z3 | | | |
| LIPS=CTB*24/22 | | | | 1.658 | | | |
| CRC1 =CTB X R | | | | 0.0 | | | |
| PRE-IOC CRC1 =CRC1 X Z6 | | | | 0.0 | | | |
| POST-IOC CRC1 =CRC1 X (1.0-Z6) | | | | 0.0 | | | |
| CUEM =DEM OR CTH*Z5/22/ENYK | | | | 0.201 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND DEM WERE 17.000000 8.000000 0.240000 | | | | | | | |
| SERVICE/DUTY CYCLE OF 4 YEARS OVER OPTION. LIFE SPAN OF 30 YEARS WITH | | | | | | | |
| MAINTENANCE | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.2.1.1.12 CARGO STORAGE DEPOTS

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|----------|------|----------------|--------------------|-----------|-----|----------|
| T= | 1.000000 | TF= | 1.000000 | CDCER= | 17.549988 | | |
| M= | 1.000000 | UEM= | 0.023400 | CDEXP= | 1.000000 | | |
| CF= | 1.000000 | Z1= | 4.000000 | CICER= | 2.340000 | | |
| PHI= | 0.950000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.0 | Z3= | 4.000000 | BYEAR= | 1979 | | |
| DF= | 0.250000 | Z4= | 4.000000 | Z5= | 0.0 | Z6= | 1.000000 |
| CALCULATED VALUES | | SET | SUM TO 1.2.1.1 | \$, MILLIONS | | | |
| CD=CDCER X (T X DF)XX(CDEXP) X CF | | | | 4.387 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 2.340 | | | |
| EORM =T / M | | | | 1.000 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 0.926 | | | |
| CTFU=(CLRM / E)X((EORM X Z1+0.5)XX(E) -0.5XX(E)) | | | | 8.844 | | | |
| CTB =((CLRM/E)X((EORM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | |) / Z3 2.211 | | | |
| CIPS=CTB*Z4/Z2 | | | | 0.147 | | | |
| CRC1 =CTB X R | | | | 0.0 | | | |
| PRE-IDC CRC1 =CRC1 X Z6 | | | | 0.0 | | | |
| POST-IDC CRC1 =CRC1 X (1.0-Z6) | | | | 0.0 | | | |
| COEM =UEM OR CTB*Z5/Z2/ENYR | | | | 0.023 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND UEM WERE 15.000000 2.000000 0.020000 | | | | | | | |
| STRUCTURE, ENCLUSURES, ELEVATORS, CONVEYORS, SPECIAL HANDLING EQUIPMENT | | | | | | | |
| 30 YEAR LIFE WITH MAINTENANCE. | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.2.1.1.13 FAB FIXTURE

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|------------|----------------|-----------|--------------------|----------|----------|----------|
| T= | 1648900.00 | TF= | 1.000000 | CDCER= | 0.026910 | | |
| M= | 5000.00000 | UEM= | 0.241251 | CDEXP= | 0.800000 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.000058 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.0 | Z3= | 1.000000 | BYEAR= | 1979 | | |
| UF= | 1.000000 | Z4= | 1.000000 | Z5= | 0.0 | Z6= | 1.000000 |
| CALCULATED VALUES | | SUM TO 1.2.1.1 | | \$,MILLIONS | | | |
| CD=CDCER X (T X UF)XX(CDEXP) X CF | | | | 2533.200 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 0.293 | | | |
| ORM =T / M | | | | 329.780 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 1.000 | | | |
| CTFU=(CLRM / E)X((ORM X Z1+0.5)XX(E) -0.5XX(E)) | | | | 96.461 | | | |
| CTB=((CLRM/E)X((ORM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | |) / Z3 | | 96.461 | |
| CIPS=CTB*Z4/Z2 | | | | 1.608 | | | |
| CRCI =CTB X R | | | | 0.0 | | | |
| PRE-IUC CRCI =CRCI X Z6 | | | | 0.0 | | | |
| POST-IUC CRCI =CRCI X (1.0-Z6) | | | | 0.0 | | | |
| UEM =UEM OR CTB*Z5/Z2/ENYK | | | | 0.241 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND OEM WERE | | | | 0.023000 | 0.000050 | 0.206197 | |
| 30 YEAR LIFE WITH MAINTENANCE | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.2.1.1.14 AIRLUCK DOCKING MODULE (ADM)

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|---|------------|------|----------------|--------------------|----------|-----|----------|
| T= | 2500.00000 | TF= | 1.000000 | CDCER= | 0.0 | | |
| M= | 2500.00000 | UEM= | 6.0 | CDEXP= | 0.0 | | |
| CF= | 1.000000 | Z1= | 17.000000 | CICER= | 0.007062 | | |
| PHI= | 0.980000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.009444 | Z3= | 34.000000 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 17.000000 | Z5= | 0.0 | Z6= | 1.000000 |
| CALCULATED VALUES | | RG | SUM TO 1.2.1.1 | 8, MILLIONS | | | |
| CD=CDCER X (T X DF)XX(CDEXP) X CF | | | | 0.0 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 17.655 | | | |
| ORM =T / M | | | | 1.000 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 0.971 | | | |
| CTFU=(CLRM / E)X(1+ORM X Z1+0.5)XX(E) -0.5XX(E) | | | | 283.493 | | | |
| CTB =((CLRM/E)X(1+ORM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | | 1 / Z3 | 16.370 | | |
| CIPS=CTB*Z4/Z2 | | | | 4.638 | | | |
| CRCI =CTB X R | | | | 0.155 | | | |
| PRE-IOC CRCI =CRCI X Z6 | | | | 0.155 | | | |
| POST-IOC CRCI =CRCI X (1.0-Z6) | | | | 0.0 | | | |
| CUEM =UEM OR CTB*Z5/Z2/ENYR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND OEM WERE | | | | 0.0 | 0.006036 | 0.0 | |
| SEE 1.2.1.2.1 FOR DDTGE. 15 YEAR LIFE. | | | | | | | |

ROCKWELL SPS CM-2 REFERENCE CONFIGURATION, 1980
TABLE 1.2.1.1.15 FASE MM1. MODULE (BMM)

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|------------|------|----------------|--------------------|----------|-----|----------|
| TF= | 27000.0000 | TF= | 1.000000 | CUCER= | 0.0 | | |
| M= | 27000.0000 | UEM= | 0.0 | COEXP= | 0.0 | | |
| CF= | 1.000000 | Z1= | 4.000000 | CICER= | 0.013450 | | |
| PHI= | 0.930000 | Z2= | 60.000000 | CIFXP= | 1.000000 | | |
| R= | 0.002220 | Z3= | 8.000000 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 4.000000 | Z5= | 0.0 | Z6= | 1.000000 |
| CALCULATED VALUES | | K6 | SUM TO 1.2.1.1 | 9, MILLIONS | | | |
| CU=CUCER X (1 X DF)XX(COEXP) X CF | | | | 0.0 | | | |
| CLRM=CICER X (M)XX(CIFXP) X CF X TF | | | | 363.159 | | | |
| BMM = 1 / M | | | | 1.000 | | | |
| E = 1.0 + LOG(PHI) / LOG(2.0) | | | | 0.971 | | | |
| CTFUM=(CLRM / E)X(BMM X Z1+0.5)XX(E) -0.5XX(E) | | | | 1420.228 | | | |
| CTB = ((CLRM/E)X(BMM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | 1 / Z3 | 349.551 | | | |
| CIPS=CTB*Z4/Z2 | | | | 23.303 | | | |
| CRC1 =CTB X R | | | | 0.776 | | | |
| PRE-IUC CRC1 =CRC1 X Z6 | | | | 0.776 | | | |
| POST-IUC CRC1 =CRC1 X (1.0-Z6) | | | | 0.0 | | | |
| CUEM =UEM OR CTE*Z5/Z2/ENVR | | | | 0.0 | | | |
| COMMENTS. | | | | | | | |
| 1977 DATA ENTERED FOR CUCER, CICER, AND UEM WERE | | | | 0.0 | 0.011496 | 0.0 | |
| SEE 1.2.2.1.1 FOR NOTICE. 15 YEARLIFE. | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.2.1.1.16 POWER MODULE (PM)

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|------------|------|----------------|--------------------|----------|-----|----------|
| T= | 250.000000 | TF= | 1.000000 | CDCER= | 0.0 | | |
| M= | 250.000000 | UEM= | 0.0 | CDEXP= | 0.0 | | |
| CF= | 1.000000 | Z1= | 4.000000 | CICER= | 1.287000 | | |
| PHI= | 0.980000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.002220 | Z3= | 8.000000 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 4.000000 | Z5= | 0.0 | Z6= | 1.000000 |
| CALCULATED VALUES | | AM | SUM TO 1.2.1.1 | \$,MILLIONS | | | |
| CU=CDCER X (T X DF)XX(CDEXP) X CF | | | | 0.0 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 321.750 | | | |
| ERM =T / M | | | | 1.000 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 0.971 | | | |
| CTFU=(CLRM / E)X((ERM X Z1+0.5)XX(E) -0.5XX(E)) | | | | 1258.288 | | | |
| CTB =((CLRM/E)X((ERM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | | 1 / Z3 | 309.693 | | |
| CIPS=CTB*Z4/Z2 | | | | 20.646 | | | |
| CRC1 =CTB X R | | | | 0.688 | | | |
| PRE-1UC CRC1 =CRC1 X Z6 | | | | 0.688 | | | |
| POST-1UC CRC1 =CRC1 X (1.0-Z6) | | | | 0.0 | | | |
| CUEM =UEM OR CTB*Z5/Z2/ENYR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND UEM WERE | | | | 0.0 | 1.100000 | 0.0 | |
| SEE 1.2.2.1.2 FOR DDT&E. 15 YEAR LIFE | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.2.1.1.17 PRESSURIZED STORAGE MODULE (PSM)

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|------------|------|----------------|--------------------|----------|-----|----------|
| T= | 15000.0000 | TF= | 1.000000 | CDCER= | 0.061909 | | |
| M= | 15000.0000 | UEM= | 0.0 | CDEXP= | 1.000000 | | |
| CF= | 1.000000 | Z1= | 4.000000 | CICER= | 0.016069 | | |
| PHI= | 0.980000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.002220 | Z3= | 8.000000 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 4.000000 | Z5= | 0.0 | Z6= | 1.000000 |
| CALCULATED VALUES | | K6 | SUM TO 1.2.1.1 | \$,MILLIONS | | | |
| CU=CDCER X (T X DF)XX(CDEXP) X CF | | | | 928.641 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 241.032 | | | |
| WRM =T / M | | | | 1.000 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 0.971 | | | |
| CTFU=(CLRM / E)X((WRM X Z1+.5)XX(E) -0.5XX(E)) | | | | 942.619 | | | |
| CTB =((CLRM/E)X((WRM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | | 1 / Z3 | 232.000 | | |
| LIPS=CTB*Z4/Z2 | | | | 15.467 | | | |
| CRC1 =CTB X R | | | | 0.515 | | | |
| PRE-IDC CRC1 =CRC1 X Z6 | | | | 0.515 | | | |
| POST-IDC CRC1 =CRC1 X (1.0-Z6) | | | | 0.0 | | | |
| LUEM =UEM OR CTR*Z5/Z2/ENYR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND UEM WERE | | | | 0.052914 | 0.013734 | 0.0 | |
| 15 YEAR LIFE | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.2.1.2.1 AIRLOCK DUCKING MODULE-ADM

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|------------|------|----------------|--------------------|----------|-----|----------|
| T= | 2500.00000 | TF= | 1.000000 | CDCER= | 0.014579 | | |
| M= | 2500.00000 | UGM= | 0.0 | CDEXP= | 1.000000 | | |
| CF= | 1.000000 | Z1= | 5.000000 | CICER= | 0.007062 | | |
| PHI= | 0.980000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.002770 | Z3= | 10.000000 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 5.000000 | Z5= | 0.0 | Z6= | 1.000000 |
| CALCULATED VALUES | | KG | SUM TO 1.2.1.2 | \$, MILLIONS | | | |
| CU=CDCER X (T X DF)XX(CDEXP) X CF | | | | 36.448 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 17.655 | | | |
| FORM = T / M | | | | 1.000 | | | |
| E = 1.0 + LOG(PHI) / LOG(2.0) | | | | 0.971 | | | |
| CTFU=(CLRM / E)X((FORM X Z1+0.5)XX(E) -0.5XX(E)) | | | | 85.893 | | | |
| CTB = ((CLRM/E)X((FORM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | 1 / Z3 | 16.902 | | | |
| LIPS=CTB*24/22 | | | | 1.408 | | | |
| CRCI = LTB X R | | | | 0.047 | | | |
| PRE-IOC CRCI =CRCI X 26 | | | | 0.047 | | | |
| POST-IOC CRCI =CRCI X (1.0-26) | | | | 0.0 | | | |
| COEM =UGM OR CTR*25/22/cMYR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND UGM WERE | | | | 0.012461 | 0.006036 | 0.0 | |
| 15 YEAR LIFE | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.2.1.2.2 CREW HABITABILITY MODULE-CMM

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|---|------------|------|----------------|--------------------|----------|-----|----------|
| T= | 27000.0000 | TF= | 1.000000 | CDLER= | 0.0 | | |
| M= | 27000.0000 | UGM= | 0.0 | CDEXP= | 0.0 | | |
| CF= | 1.000000 | Z1= | 17.000000 | CICER= | 0.004411 | | |
| PHI= | 0.980000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.009444 | Z3= | 34.000000 | BVEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 17.000000 | 25= | 0.0 | 26= | 1.000000 |
| CALCULATED VALUES | | K6 | SUM TO 1.2.1.2 | \$,MILLIONS | | | |
| CU=CDLER X (T X DF)X(CDEXP) X CF | | | | 0.0 | | | |
| CLRM=CICER X (M)X(CIEXP) X CF X TF | | | | 119.094 | | | |
| BPM =T / M | | | | 1.000 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 0.971 | | | |
| CTFU=(CLRM / E)X(BPM X (1+.5)X(E) -0.5X(E)) | | | | 1912.313 | | | |
| CTB =((CLRM/E)X(BPM X (23 + 0.5)X(E) -0.5X(E)) | | | | 1 / 23 | 110.427 | | |
| CIPS=CTB*24/22 | | | | 31.288 | | | |
| CRC1 =CTB X R | | | | 1.043 | | | |
| PRE-10C CRC1 =CRC1 X 26 | | | | 1.043 | | | |
| POST-10C CRC1 =CRC1 X (1.0-26) | | | | 0.0 | | | |
| UGM =UGM OR CTR*25/22/ENYR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDLER, ICER, AND UGM WERE | | | | 0.0 | 0.003770 | 0.0 | |
| SEE 1.2.2.2.1 FOR DDTC. 15 YEAR LIFE | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.2.1.2.3 CONSUMABLES LOGISTICS MODULE-CLM

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|------------|------|----------------|--------------------|----------|-----|----------|
| T= | 5000.00000 | TF= | 1.000000 | CDCER= | 0.0 | | |
| M= | 5000.00000 | UEM= | 0.0 | CDEXP= | 0.0 | | |
| CF= | 1.000000 | Z1= | 9.000000 | CICER= | 0.016380 | | |
| PHI= | 0.980000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.005000 | Z3= | 18.000000 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 9.000000 | 25= | 0.0 | Z6= | 1.000000 |
| CALCULATED VALUES | | K6 | SUM TO 1.2.1.2 | \$,MILLIONS | | | |
| CU=CDCER X (T X DF)XX(CDEXP) X CF | | | | 0.0 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 81.900 | | | |
| ORM =T / M | | | | 1.000 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 0.971 | | | |
| CTFU=(CLRM / E)X((ORM X Z1+0.5)XX(E) -0.5XX(E)) | | | | 707.469 | | | |
| CTB =((CLRM/E)X((ORM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | | 1 / Z3 77.242 | | | |
| LIPS=CTB*24/22 | | | | 11.586 | | | |
| CRCI =CTB X R | | | | 0.386 | | | |
| PRE-IUC CRCI =CRCI X Z6 | | | | 0.386 | | | |
| POST-IUC CRCI =CRCI X (1.0-Z6) | | | | 0.0 | | | |
| COEM =UEM OR LTB*25/22/ENYR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND UEM WERE | | | | 0.0 | 0.014000 | 0.0 | |
| SEE 1.2.2.2.2 FOR DDICE. 15 YEAR LIFE. | | | | | | | |

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ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.2.1.2.4 SHIELDING

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|---|------------|------|-----------|--------------------|--------------|----------|----------|
| T= | 11000.0000 | TF= | 1.000000 | CDCER= | | 0.182520 | |
| M= | 11000.0000 | UEM= | 0.0 | CDEXP= | | 1.000000 | |
| CF= | 1.000000 | Z1= | 8.000000 | CICER= | | 0.118170 | |
| PHI= | 0.920000 | Z2= | 60.000000 | CIEXP= | | 0.355000 | |
| R= | 0.004440 | Z3= | 16.000000 | BYEAR= | | 1979 | |
| DF= | 0.200000 | Z4= | 8.000000 | Z5= | 0.0 | Z6= | 1.000000 |
| CALCULATED VALUES | | KG | SUM T(1) | 1.2.1.2 | \$, MILLIONS | | |
| CU=CDCER X (T X DF) X X(CDEXP) X CF | | | | | 401.544 | | |
| CLRM=CICER X (M) X X(CIEXP) X CF X TF | | | | | 3.215 | | |
| E = 1.0 + LOG(PHI) / LOG(2.0) | | | | | 0.971 | | |
| CIFU=(CLRM / E) X ((ORM X (Z1+0.5) X X(E) -0.5 X X(E))) | | | | | 24.757 | | |
| CTB = ((CLRM/E) X ((ORM X (Z3 + 0.5) X X(E) -0.5 X X(E))) | | | | 1 / Z3 | 3.042 | | |
| CIPS=CTB*24/22 | | | | | 0.406 | | |
| CRC1 =CTB X R | | | | | 0.014 | | |
| PRE-10C CRC1 =CRC1 X Z6 | | | | | 0.014 | | |
| POST-10C CRC1 =CRC1 X (1.0-Z6) | | | | | 0.0 | | |
| CUEM =UEM OR CTB*25/22/ENYR | | | | | 0.0 | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND UEM WERE | | | | 0.156000 | 0.101000 | 0.0 | |
| 15 YEAR LIFE | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.2.1.2.5 CREW SUPPORT MODULE-CSM

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|------------|------|----------------|--------------------|----------|----------|----------|
| T= | 15000.0000 | TF= | 1.000000 | CDLER= | | 0.014545 | |
| M= | 15000.0000 | UEM= | 0.0 | CDEXP= | | 1.000000 | |
| CF= | 1.000000 | Z1= | 3.000000 | CICER= | | 0.006784 | |
| PHI= | 0.980000 | Z2= | 60.000000 | CIEXP= | | 1.000000 | |
| R= | 0.001666 | Z3= | 6.000000 | BYEAR= | | 1979 | |
| DF= | 1.000000 | Z4= | 3.000000 | Z5= | 0.0 | Z6= | 1.000000 |
| CALCULATED VALUES | | AG | SUM TO 1.2.1.2 | \$,MILLIONS | | | |
| CU=CDLER X (T X DF)XX(CDEXP) X CF | | | | 218.182 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 101.755 | | | |
| URM =T / M | | | | 1.000 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 0.971 | | | |
| CTFU=(CLRM / E)X(URM X Z1+0.5)XX(E) -0.5XX(E) | | | | 300.206 | | | |
| CTB =((CLRM/E)X(URM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | | 1 / Z3 | 98.603 | | |
| CIPS=CTB*Z4/Z2 | | | | 4.930 | | | |
| CRCI =CTB X R | | | | 0.164 | | | |
| PRE-IOC CRCI =CRCI X Z6 | | | | 0.164 | | | |
| POST-IOC CRCI =CRCI X (1.0-Z6) | | | | 0.0 | | | |
| COEM =DEM OR CTH*Z5/Z2/ENYR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND UEM WERE | | | | 0.012432 | 0.005798 | 0.0 | |
| 15 YEAR LIFE | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.2.1.3.1 OPERATIONS, CONSTRUCTION CREW

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|------------|------|----------------|--------------------|----------|--------|----------|
| T= | 1268.00000 | TF= | 1.000000 | CD CER= | 0.0 | | |
| M= | 1.000000 | UEM= | 0.0 | CD EXP= | 0.0 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.073608 | | |
| Phi= | 1.000000 | Z2= | 60.000000 | CI EXP= | 1.000000 | | |
| R= | 0.0 | Z3= | 31.000000 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 30.000000 | Z5= | 0.0 | Z6= | 1.000000 |
| CALCULATED VALUES | | MEN | SUM TO 1.2.1.3 | \$, MILLIONS | | | |
| CU=CD CER X (T X DF)XX(CD EXP) X CF | | | | 0.0 | | | |
| CLRM=CICER X (M)XX(CI EXP) X CF X TF | | | | 0.073 | | | |
| BPM =T / M | | | | 1268.000 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 1.000 | | | |
| CTFU=(CLRM / E)X((BPM X Z1+.5)XX(E) -0.5XX(E)) | | | | 92.574 | | | |
| CTB =((CLRM/E)X((BPM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | |) / Z3 | | 92.574 | |
| CIPS=CTB*Z4/Z2 | | | | 46.287 | | | |
| CRC1 =CTB X R | | | | 0.0 | | | |
| PRE-10C CRC1 =CRC1 X Z6 | | | | 0.0 | | | |
| POST-10C CRC1 =CRC1 X (1.0-Z6) | | | | 0.0 | | | |
| COEM =UEM OR LIM*Z5/Z2/ENYK | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CD CER, CICER, AND UEM WERE 0.0 0.062400 0.0 | | | | | | | |
| TFU REQUIRES ONE YEAR TO BUILD. 60 SATELLITE OPTION BUILT AT RATE OF 2 | | | | | | | |
| PER YEAR. | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.2.1.3.2 ORBITAL OPERATIONS, CONST. PROV.

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|------------|------|----------------|--------------------|----------|--------|----------|
| T= | 1643328.00 | TF= | 1.000000 | CDCER= | 0.0 | | |
| M= | 3.600000 | CLM= | 0.0 | CDEXP= | 0.0 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.000026 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.0 | Z3= | 31.000000 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 30.000000 | Z5= | 0.0 | Z6= | 1.000000 |
| CALCULATED VALUES | | KG | SUM TO 1.2.1.3 | \$, MILLIONS | | | |
| CD=CDCER X (1 X DF)XX(CDEXP) X CF | | | | 0.0 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 0.000 | | | |
| ORM =T / M | | | | 456479.937 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 1.000 | | | |
| CTFU=(CLRM / E)X((ORM X Z1+0.5)XX(E) -0.5XX(E)) | | | | 42.299 | | | |
| CTB =((CLRM/E)X((ORM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | |) / Z3 | | 42.299 | |
| CIPS=CTB*Z4/Z2 | | | | 21.150 | | | |
| CRC1 =CTB X R | | | | 0.0 | | | |
| PRE-IDC CRC1 =CRC1 X Z6 | | | | 0.0 | | | |
| POST-IDC LNC1 =CRC1 X (1.0-Z6) | | | | 0.0 | | | |
| OEM =OEM OR CTB*Z5/Z2/ENYR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND OEM WERE 0.0 0.000022 0.0 | | | | | | | |
| 1643328 KG OF PROVISIONS ANNUALLY FOR TOTAL OF A 1268 PERSON CREW. | | | | | | | |
| 826 KG AT 3.6 KG/PERSON/DAY | | | | | | | |

1.2.2 LOGISTICS SUPPORT FACILITIES—LEO

This element includes hardware, software and operations required in LEO to support construction and operations/maintenance of the satellite system. Included are crew life support facilities, cargo and propellant depots, and vehicle servicing facilities necessary for the transfer of cargo and personnel destined for a construction mobile maintenance base activity in GEO.

LEO support operations require a permanent crew of 30. These personnel provide supervision over the transfer of payloads between the HLLV and OTV's. They also perform scheduled maintenance required by the electric propulsion OTV such as the changeout of ion thruster screens. Included are work and crew support facilities (Table 1.2-4) plus required operational support.

Table 1.2-4. LEO Base Modules

| SYSTEM DESCRIPTION | WORK SUPPORT FACILITIES | CREW SUPPORT FACILITIES |
|------------------------------------|-------------------------------|-------------------------------|
| CREW HABITABILITY MODULE (CHM) | | 1 |
| CONSUMABLES LOGISTICS MODULE (CLM) | | 1 |
| BASE MANAGEMENT MODULE (BMM) | 1 | |
| CREW SUPPORT MODULE/EVA (CSM/EVA) | | 1 |
| POWER MODULE (PM) | 1 | |
| AIRLOCK DOCKING MODULE (ADM) | 1 | |

1.2.2.1 WORK SUPPORT FACILITIES

This element includes facilities and equipment required to provide logistics support in LEO. Included are HLLV and OTV docking stations, payload handling equipment, and cargo and propellant storage depots. Excluded are facilities related to crew support. A 100 kW solar array power module, the airlock docking module, and a base management module are work support facilities. Cost estimates were based on Rockwell Space Station studies.

1.2.2.2 CREW SUPPORT FACILITIES

This element includes facilities and equipment required for the life support and well-being of the crew members. Included are living quarters, recreation facilities, and health facilities at LEO.

The crew habitability module and crew support module/EVA are the same basic configuration as for those on the SCB. However, the crew support module has an airlock and EVA preparation area. A consumables logistics module is the third element of crew support facilities. CERs used for crew support facilities were based upon Rockwell Space Station studies.

1.2.2.3 OPERATIONS

This element includes planning, development, and conduct of operations at the logistics support facility. It includes both direct and support personnel and the expendable maintenance supplies required for logistics support.

An average of 30 crew members are required at the LEO Base to support orbital operations. Engineering estimates were made of the operations and consumable requirements at LEO.

1.2.2.4 COST ESTIMATES

LEO base cost estimates covering work, crew, and operational elements are included in Table 1.2-5.

Table 1.2-5. LEO Base Cost Estimates

| WBS TABLE NO's | DESCRIPTION |
|--|-------------------------|
| 1.2.2.1.1, 1.2.2.1.2, and 1.2.2.1.3 | Work Support Facilities |
| 1.2.2.2.1, 1.2.2.2.2, and 1.2.2.2.3 | Crew Support Facilities |
| 1.2.2.3.1, 1.2.2.3.2 | Operations |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.2.2.1.1 BASE MGMT. MODULE-BMM

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|---|------------|------|----------------|--------------------|----------|-----|----------|
| T= | 27000.0000 | 1F= | 1.000000 | CDCER= | 0.106816 | | |
| M= | 27000.0000 | UEM= | 0.0 | CDEXP= | 1.000000 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.013450 | | |
| PHI= | 0.980000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.000555 | Z3= | 2.000000 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 0.800000 | Z5= | 0.200000 | Z6= | 0.800000 |
| CALCULATED VALUES | | K6 | SUM TO 1.2.2.1 | 8, MILLIONS | | | |
| CD=CDCER X (T X DF)XX(CDEXP) X CF | | | | 2884.040 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X 1F | | | | 363.159 | | | |
| URM = T / M | | | | 1.000 | | | |
| E = 1.0 + LOG(PHI) / LOG(2.0) | | | | 0.971 | | | |
| CTFU=(CLRM / E)X(URM X Z1+.5)XX(E) -0.5XX(E) | | | | 363.652 | | | |
| CTB =(CLRM/E)X(URM X Z3 + 0.5)XX(E) -0.5XX(E) | | | | 1 / Z3 | 359.830 | | |
| CIPS=CTB*Z4/Z2 | | | | 4.798 | | | |
| CRC1 =CTB X R | | | | 0.200 | | | |
| PRE-IOC CRC1 =CRC1 X Z6 | | | | 0.160 | | | |
| POST-IOC CRC1 =CRC1 X (1.0-Z6) | | | | 0.040 | | | |
| COCM =UEM OR CTB*Z5/Z2/ENVR | | | | 0.040 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND UEM WERE 0.091296 0.011496 0.0 | | | | | | | |
| 15 YEAR LIFE. 80 PERCENT OF BMM ASSOCIATED WITH CONSTRUCTION ACTIVITIES | | | | | | | |

HUCKWELL SFS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.2.2.1.2 POWER MODULE-PM

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|---|------------|------|----------------|--------------------|----------|-----|----------|
| T= | 250.000000 | TF= | 1.000000 | CDCER= | 1.638000 | | |
| M= | 250.000000 | UGM= | 0.0 | CDEXP= | 1.000000 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 1.287000 | | |
| PHI= | 0.980000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.000555 | Z3= | 2.000000 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 0.800000 | Z5= | 0.200000 | Z6= | 0.800000 |
| CALCULATED VALUES | | AW | SUM TO 1.2.2.1 | \$, MILLIONS | | | |
| CD=CDCER X (T X UF)XX(CDEXP) X CF | | | | 409.500 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 321.750 | | | |
| ORM =T / M | | | | 1.000 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 0.971 | | | |
| CTFU=(CLRM / E)X(1+ORM X Z1+.5)XX(E) -0.5XX(E) | | | | 322.187 | | | |
| CTM =(1+CLRM/E)X(1+ORM X Z3 + 0.5)XX(E) -0.5XX(E) | | | | 318.801 | | | |
| CIPS=CTB*Z4/Z2 | | | | 4.251 | | | |
| CRC1 =CTB X R | | | | 0.177 | | | |
| PRE-IOC CRC1 =CRC1 X Z6 | | | | 0.142 | | | |
| POST-IOC CRC1 =CRC1 X (1.0-Z6) | | | | 0.035 | | | |
| COEM =UGM OR CTB*Z5/Z2/ENYR | | | | 0.035 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND UGM WERE 1.400000 1.100000 0.0 | | | | | | | |
| 15 YEAR LIFE. 80 PERCENT OF PM ASSOCIATED WITH CONSTRUCTION ACTIVITIES. | | | | | | | |

KOLKWEILL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.2.2.1.3 AIRLUCK DOCKING MODULE - ADM

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|------------|------|----------------|--------------------|----------|-----|----------|
| T= | 2500.00000 | IF= | 1.000000 | CDCER= | 0.0 | | |
| M= | 2500.00000 | LEM= | 0.0 | COEXP= | 0.0 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.007062 | | |
| PHI= | 0.980000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.000555 | Z3= | 2.000000 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 0.800000 | Z5= | 0.200000 | Z6= | 0.800000 |
| CALCULATED VALUES | | K6 | SUM TO 1.2.2.1 | \$,MILLIONS | | | |
| CD=CDCER X (T X DF)XX(COEXP) X CF | | | | 0.0 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X IF | | | | 17.655 | | | |
| ORM = T / M | | | | 1.000 | | | |
| E = 1.0 + LOG(PHI) / LOG(2.0) | | | | 0.971 | | | |
| CTFU=(CLRM / E)X((ORM X Z1+.5)XX(E) -0.5XX(E)) | | | | 17.679 | | | |
| CTB =(CLRM/E)X((ORM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | | 1 / Z3 17.493 | | | |
| CIPS=CTB*Z4/Z2 | | | | 0.233 | | | |
| CRC1 =CTB X R | | | | 0.010 | | | |
| PRE-IOC CRC1 =CRC1 X Z6 | | | | 0.008 | | | |
| POST-IOC CRC1 =CRC1 X (1.0-Z6) | | | | 0.002 | | | |
| COEM =OEM OR CTB*Z5/Z2/ENVR | | | | 0.002 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND OEM WERE 0.0 0.006036 0.0 | | | | | | | |
| SEE 1.2.1.2.1 FOR DOTE, 15 YEAR LIFE, 80 PERCENT OF ADM ASSOCIATED | | | | | | | |
| WITH CONSTRUCTION ACTIVITIES | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980

TABLE 1.2.2.2.1 CREW HABITABILITY MODULE-CHM

INPUT PARAMETERS

| | | | |
|------|------------|------|-----------|
| T= | 27000.0000 | TF= | 1.000000 |
| M= | 27000.0000 | CEM= | 0.0 |
| CF= | 1.000000 | Z1= | 1.000000 |
| PHI= | 0.980000 | Z2= | 60.000000 |
| R= | 0.000550 | Z3= | 2.000000 |
| DF= | 1.000000 | Z4= | 0.800000 |

INPUT COEFFICIENTS

| | |
|--------|----------|
| CDCER= | 0.011365 |
| CDEXP= | 1.000000 |
| CICER= | 0.004411 |
| CIEXP= | 1.000000 |
| BYEAR= | 1979 |
| Z5= | 0.200000 |
| Z6= | 0.800000 |

CALCULATED VALUES

RG

SUM TO 1.2.2.2

\$, MILLIONS

CD=CDCER X (T X DF)XX(CDEXP) X CF 306.865

CLRM=CICER X (M)XX(CIEXP) X LF X TF 119.094

ORM = T / M 1.000

E = 1.0 + LOG(PHI) / LOG(2.0) 0.971

CIFU=(CLRM / E)X(ORM X Z1+.5)XX(E) -0.5XX(E) 119.256

CTB = ((CLRM/E)X((ORM X Z3 + 0.5)XX(E) -0.5XX(E)) 1 / Z3 118.003

CIPS=CTB*Z4/Z2 1.573

CRC1 =CTB X R 0.065

PRE-IDC CRC1 =CRC1 X Z6 0.052

POST-IDC CRC1 =CRC1 X (1.0-Z6) 0.013

CEM =CEM OR CTB*Z5/Z2/ENVR 0.013

COMMENTS

1977 DATA ENTERED FOR CDCER, CICER, AND CEM WERE 0.009714 0.003770 0.0
15 YEAR LIFE. RG PERCENT OF CHM ASSOCIATED WITH CONSTRUCTION
ACTIVITIES.

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.2.2.2.2 CONSUMABLES LOGISTICS MODULE CLM

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | | |
|--|------------|------|----------------|--------------------|----------|-----|----------|--------|
| T= | 5000.00000 | TF= | 1.000000 | CDCER= | 0.062010 | | | |
| M= | 5000.00000 | DEM= | 0.0 | CDEXP= | 1.000000 | | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.016380 | | | |
| PHI= | 0.960000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | | |
| R= | 0.000555 | Z3= | 2.000000 | BYEAR= | 1979 | | | |
| DF= | 1.000000 | Z4= | 0.800000 | Z5= | 0.200000 | Z6= | 0.800000 | |
| CALCULATED VALUES | | KG | SUM TO 1.2.2.2 | \$, MILLIONS | | | | |
| CD=CDCER X (T X DF)XX(CDEXP) X CF | | | | 310.050 | | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 81.900 | | | | |
| ARM =T / M | | | | 1.000 | | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 0.971 | | | | |
| CTFU=(CLRM / E)X((ARM X Z1+.5)XX(E) -0.5XX(E)) | | | | 82.011 | | | | |
| CTB =((CLRM/E)X((ARM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | | 1 / Z3 | | | | 81.149 |
| CIPS=CTB*24/22 | | | | 1.082 | | | | |
| CRC1 =CTB X R | | | | 0.045 | | | | |
| PRE-IOC CRC1 =CRC1 X Z6 | | | | 0.036 | | | | |
| POST-IOC CRC1 =CRC1 X (1.0-Z6) | | | | 0.009 | | | | |
| CDEM =DEM OR CTB*25/22/ENYR | | | | 0.009 | | | | |
| COMMENTS | | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND DEM WERE 0.053000 0.014000 0.0 | | | | | | | | |
| 15 YEAR LIFE. 80 PERCENT OF CLM ASSOCIATED WITH CONSTRUCTION | | | | | | | | |
| ACTIVITIES. | | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.2.2.2.3 CREW SUPPORT MODULE/EVA

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|------------|------|----------------|--------------------|----------|---------|----------|
| T= | 27000.0000 | TF= | 1.000000 | CDCER= | 0.014545 | | |
| M= | 27000.0000 | UEM= | 0.0 | COEXP= | 1.000000 | | |
| CF= | 1.000000 | L1= | 1.000000 | CICER= | 0.006784 | | |
| Phi= | 0.980000 | L2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.000555 | L3= | 2.000000 | BYEAR= | 1979 | | |
| DF= | 1.000000 | L4= | 0.800000 | Z5= | 0.200000 | Z6= | 0.800000 |
| CALCULATED VALUES | | KG | SUM TO 1.2.2.2 | \$, MILLIONS | | | |
| CD=CDCER X (T X DF)XX(COEXP) X CF | | | | 392.727 | | | |
| CLRM=CICER X (M)XX(CIEXP) X L1 X TF | | | | 183.159 | | | |
| FORM = T / M | | | | 1.000 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 0.971 | | | |
| CTFU=(CLRM / E)X((FORM X L1+.5)XX(E) -0.5XX(E)) | | | | 183.408 | | | |
| CTB =((CLRM/E)X((FORM X L3 + 0.5)XX(E) -0.5XX(E)) | | | | 1 / L3 | | 181.480 | |
| CIPS=CTB*24/22 | | | | 2.420 | | | |
| CRC1 =CTB X R | | | | 0.101 | | | |
| PRE-IOC CRC1 =CRC1 X Z6 | | | | 0.081 | | | |
| POST-IOC CRC1 =CRC1 X (1.0-Z6) | | | | 0.020 | | | |
| COEM =UEM OR C1B*25/22/ENYR | | | | 0.020 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND UEM WERE 0.012432 0.005798 0.0 | | | | | | | |
| 15 YEAR LIFE. 80 PERCENT OF CSM/EVA ASSOCIATED WITH CONSTRUCTION ACTIVITIES. | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.2.2.3.1 LEO OPERATIONS CREW

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|---|-----------|---------|----------------|--------------------|----------|-----|----------|
| T= | 30.000000 | TF= | 1.000000 | CDCER= | 0.0 | | |
| M= | 1.000000 | OGM= | 0.0 | CDEXP= | 0.0 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.073008 | | |
| PHI= | 1.000000 | Z2= | 00.000000 | CIEXP= | 1.000000 | | |
| R= | 0.0 | Z3= | 30.500000 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 24.000000 | Z5= | 6.000000 | Z6= | 0.800000 |
| CALCULATED VALUES | | PERSONS | SUM TO 1.2.2.3 | 8, MILLIONS | | | |
| CD=CDCER X (T X DF)XX(CDEXP) X CF | | | | 0.0 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 0.073 | | | |
| ORM =T / M | | | | 30.000 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 1.000 | | | |
| CTFU=(CLRM / E)X(ORM X Z1+.5)XX(E) -0.5XX(E) | | | | 2.190 | | | |
| CTB =((CLRM/E)X(ORM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | | 1 / Z3 2.190 | | | |
| CIPS=CTB*Z4/Z2 | | | | 0.876 | | | |
| CRC1 =CTB X R | | | | 0.0 | | | |
| PRE-IOC CRC1 =CRC1 X Z6 | | | | 0.0 | | | |
| POST-IOC CRC1 =CRC1 X (1.0-Z6) | | | | 0.0 | | | |
| CUEM =UEM OR CTB*Z5/Z2/ENR | | | | 0.007 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND OGM WERE 0.0 0.062400 0.0 | | | | | | | |
| 30 PERSON CREW AT LEU. 80 PERCENT OF CREW ASSOCIATED WITH CONSTRUCTION ACTIVITIES | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.2.2.3.2 LEO CREW PROVISIONS

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|---|------------|------|----------------|--------------------|----------|-----|----------|
| T= | 38880.0000 | TF= | 1.000000 | CDCER= | 0.0 | | |
| M= | 3.600000 | UEM= | 0.0 | COEXP= | 0.0 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.000026 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.0 | Z3= | 30.500000 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 24.000000 | Z5= | 6.000000 | Z6= | 0.800000 |
| CALCULATED VALUES | | KG | SUM TO 1.2.2.3 | \$, MILLIONS | | | |
| CU=CDCER X (T X DF)XX(COEXP) X CF | | | | 0.0 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 0.000 | | | |
| EORM =T / M | | | | 10799.996 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 1.000 | | | |
| CTFU=(CLRM / E)X((EORM X Z1+0.5)XX(E) -0.5XX(E)) | | | | 1.001 | | | |
| CTB =(1CLRM/E)X((EORM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | 1 / Z3 | 1.001 | | | |
| CIPS=CTB*24/Z2 | | | | 0.400 | | | |
| CRC1 =CTB X R | | | | 0.0 | | | |
| PRE-IUC CRC1 =CRC1 X Z6 | | | | 0.0 | | | |
| POST-IUC CRC1 =CRC1 X (1.0-Z6) | | | | 0.0 | | | |
| CUEM =UEM OR CTH*Z5/Z2/ENVR | | | | 0.003 | | | |
| COMMENTS | | | | | | | |
| 1979 DATA ENTERED FOR CDCER, CICER, AND UEM WERE . . 0.0 . . 0.000022 . . 0.0 | | | | | | | |
| 826/KG AT 3.6 KG/PERSON/DAY. 30 PERSON CREW. 80 PERCENT OF CREW | | | | | | | |
| PROVISIONS ASSOCIATED WITH CONSTRUCTION ACTIVITIES. | | | | | | | |

1.2.3 SATELLITE O&M SUPPORT FACILITIES

This element includes the facilities, equipment, and operations required in GEO to support operations and maintenance of satellite systems after IOC. Included are on-orbit monitor and control facilities, life support facilities, and equipment required to provide comfortable safe living quarters for resident crew members during O&M activities, plus storage module facilities.

Post IOC-O&M activity and the replacement of capital investment systems is carried out under the concept of mobile maintenance facilities traveling from satellite to satellite by using the SCB as a home base. Table 1.2-6 identifies work and crew support facilities associated with SCB and MMB missions.

Table 1.2-6. Satellite O&M Facilities

| SYSTEM DESCRIPTION | ABBREVIATION | WORK SUPPORT FACILITIES | CREW SUPPORT FACILITIES |
|------------------------------|--------------|-------------------------|-------------------------|
| AIRLOCK DOCKING MODULE | ADM | 12 | |
| CREW HABITABILITY MODULE | CHM | | 8 |
| CONSUMABLES LOGISTICS MODULE | CLM | | 8 |
| BASE MANAGEMENT MODULE | BMM | 64 | |
| POWER MODULE | PM | 12 | |
| PRESSURIZED STORAGE MODULE | PSM | 12 | |

A mobile maintenance base is scheduled to provide an average of 45 days of service to individual satellites on an annual rotation basis. Table 1.2-7 identifies MMB rotations against a satellite option and summarizes crew requirements for SCB and MMB categories.

1.2.3.1 WORK SUPPORT FACILITIES

This element includes work oriented facilities and equipment required at the SCB and on the MMB, along with those needed at the satellite to satisfy operational and maintenance needs of the satellite system during its operation.

Of the 12 ADM's (reference Table 1.2-7) - 4 are located on the SCB and 8 are located on the contingent of MMB's (mobile maintenance bases). Sixty MMB's are assigned as one per satellite with 4 more located in the SCB. Four PM's, and PSM's are located on the SCB to support satellite O&M activity for the option. One set each of the other 8 PM's and PSM's is located on the individual MMB's. One CHM and CLM is also located on each of the MMB's.

Table 1.2-7. MMB Requirements

| CONSTRUCTION PERIOD (YEARS) | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | |
|-----------------------------|----|----|----|----|-----------------|----|----|----|-----------------|----|----|----|------------------|-----|-----|-----|-------------------|-----|-----|-----|-----|-------------------|-----|-----|-----------------|-------------------|-----|-----|-----|-------------------|-----|-----|
| SATELLITE IOC's | 1 | 3 | 5 | 7 | 9 | 11 | 13 | 15 | 17 | 19 | 21 | 23 | 25 | 27 | 29 | 31 | 33 | 35 | 37 | 39 | 41 | 43 | 45 | 47 | 49 | 51 | 53 | 55 | 57 | 59 | 61 | |
| MMB 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| MMB 2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| MMB 3 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| MMB 4 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| MMB 5 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| MMB 6 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| MMB 7 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| MMB 8 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CREW | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| SCB | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | $\frac{8}{16}$ | 16 | 16 | 16 | 16 | 16 | 16 | 16 | $\frac{16}{24}$ | 24 | 24 | 24 | 24 | 24 | 24 | 24 | $\frac{24}{32}$ | 32 | 32 | 32 | 32 | 32 | 32 | |
| MMB | 30 | 30 | 30 | 30 | $\frac{30}{60}$ | 60 | 60 | 60 | $\frac{60}{90}$ | 90 | 90 | 90 | $\frac{90}{120}$ | 120 | 120 | 120 | $\frac{120}{150}$ | 150 | 150 | 150 | 150 | $\frac{150}{180}$ | 180 | 180 | 180 | $\frac{180}{210}$ | 210 | 210 | 210 | $\frac{210}{240}$ | 240 | 240 |

The MMB located on each satellite incorporates a monitoring and fault isolation capability for SPS satellite subsystems as well as the controls required for alternate operational modes and functional isolation of selected subsystems for maintenance. CER's are based on Rockwell Space Station study data.

1.2.3.2 CREW SUPPORT FACILITIES

This element includes facilities and equipment required for life support and well-being of the crew members. Included are living quarters, recreation facilities, and health facilities located on the MMB. Costs of CHM and CLM modules are based on Rockwell's Space Station studies.

1.2.3.3 OPERATIONS

This element includes the planning, development, and conduct of operations at the O&M support facility. It encompasses both direct and indirect personnel plus expendable maintenance supplies required in GEO for satellite operations and maintenance.

O&M crew are located on the SCB and MMB. Each satellite is serviced for an average period of 45 days per year.

1.2.3.4 COST ESTIMATES

Operational support costs are identified in Table 1.2-8.

Table 1.2-8. Operational Cost Tables

| WBS TABLE NO's | DESCRIPTION |
|--|-------------------------|
| 1.2.3.1.1 thru 1.2.3.1.4 | Work Support Facilities |
| 1.2.3.2.1, 1.2.3.2.2 | Crew Support Facilities |
| 1.2.3.3.1 (SCB Crew), 1.2.3.3.2 (MMB Crew), 1.2.3.3.3 (SCB Provisions) 1.2.3.3.4 (MMB Provisions) | Operations |

ROCKWELL SPS CP-2 REFERENCE CONFIGURATION, 1980
TABLE 1.2.3.1.1 AIRLUCK DUCKING MODULE-ADM

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | | |
|---|------------|------|----------------|--------------------|-----------|-----|-----|--------|
| T= | 2500.00000 | TF= | 1.000000 | CDLER= | 0.0 | | | |
| M= | 2500.00000 | UEM= | 0.0 | CDEXP= | 0.0 | | | |
| CF= | 1.000000 | Z1= | 2.000000 | CICER= | 0.007062 | | | |
| PHI= | 0.980000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | | |
| R= | 0.006666 | Z3= | 24.000000 | BYEAR= | 1979 | | | |
| DF= | 1.000000 | Z4= | 0.0 | 25= | 12.000000 | 26= | 0.0 | |
| CALCULATED VALUES | | KL | SUM TO 1.2.3.1 | \$, MILLIONS | | | | |
| LD=CDLER X (T X DF)X(CDEXP) X CF | | | | 0.0 | | | | |
| CLRM=CICER X (M)X(CIEXP) X CF X TF | | | | 17.655 | | | | |
| ORM = T / M | | | | 1.000 | | | | |
| E = 1.0 + LOG(PHI) / LOG(2.0) | | | | 0.971 | | | | |
| CTFU=(CLRM / E)X(ORM X Z1+0.5)X(E) -0.5X(E) | | | | 34.987 | | | | |
| CTB =((CLRM/E)X(ORM X Z3 + 0.5)X(E) -0.5X(E)) | | | | 1 / Z3 | | | | 16.525 |
| CIPS=CTB*Z4/Z2 | | | | 0.0 | | | | |
| CRC1 =CTB X R | | | | 0.110 | | | | |
| PRE-IDC CRC1 =CRC1 X Z6 | | | | 0.0 | | | | |
| POST-IDC CRC1 =CRC1 X (1.0-Z6) | | | | 0.110 | | | | |
| UEM =DEM UR LTR=Z5/Z2/ENR | | | | 0.110 | | | | |
| COMMENTS | | | | | | | | |
| 1977 DATA ENTERED FOR CDLER, CICER, AND UEM WERE 0.0 0.006036 0.0 | | | | | | | | |
| SEE 1.2.1-2.1 FOR DDILE. 15 YEAR LIFE. 4 ADM'S LOCATED ON SCB. | | | | | | | | |
| 8 ADM'S FOR MMR'S. ONE ADM ON SLB AND ONE ADM ON MMB FOR TPU | | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.2.3.1.2 BASE MGM1 MODULE-BMM

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|---|------------|----------------|------------|--------------------|-----------|-----|-----|
| T= | 27000.0000 | TF= | 1.000000 | CDCER= | 0.0 | | |
| M= | 27000.0000 | UEM= | 0.0 | CDEXP= | 0.0 | | |
| CF= | 1.000000 | Z1= | 2.000000 | CICER= | 0.013450 | | |
| PHI= | 0.900000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.035555 | Z3= | 128.000000 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 0.0 | Z5= | 64.000000 | Z6= | 0.0 |
| CALCULATED VALUES | | SUM TO 1.2.3.1 | | \$, MILLIONS | | | |
| CU=CDCER X (T X DF)XX(CDEXP) X CF | | | | 0.0 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 363.159 | | | |
| E = 1.0 + LOG(PHI) / LOG(2.0) | | | | 0.971 | | | |
| CTFU=(CLRM / E)X(UEM X Z1+0.5)XX(E) -0.5XX(E) | | | | 719.661 | | | |
| CTB =(CLRM/E)X(UEM X Z3 + 0.5)XX(E) -0.5XX(E) | | | | 324.472 | | | |
| CIPS=CTB*Z4/Z2 | | | | 0.0 | | | |
| CRC1 =CTB X R | | | | 11.537 | | | |
| PRE-IUC CRC1 =CRC1 X Z6 | | | | 0.0 | | | |
| POST-IUC LRC1 =CRC1 X (1.0-Z6) | | | | 11.537 | | | |
| COEM =UEM OR CTB*Z5/Z2/ENYR | | | | 11.537 | | | |

COMMENTS

1977 DATA ENTERED FOR CDCER, CICER, AND UEM WERE 0.0 0.011496 0.0
SEE 1.2.2.1.1 FOR DDTCE. 15 YEAR LIFE. ONE BMM LOCATED ON SCB FOR TFC.
1BMM LOCATED ON EACH SATELLITE. 1BMM LOCATED ON SCB TO SUPPORT
DEM ACTIVITIES FOR 15 SATELLITES.

ROCKWELL SPS LK-2 REFERENCE CONFIGURATION, 1980
TABLE 1.2.3.1.3 PRESSURIZED STORAGE MODULE-PSM

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|------------|------|----------------|--------------------|----------|---------|-----|
| T= | 15000.0000 | IF= | 1.000000 | CDCER= | 0.0 | | |
| M= | 15000.0000 | UEM= | 0.0 | CDEXP= | 0.0 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICFR= | 0.016069 | | |
| PHI= | 0.980000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.002222 | Z3= | 8.000000 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 0.0 | Z5= | 4.000000 | Z6= | 0.0 |
| CALCULATED VALUES | | KG | SUM TO 1.2.3.1 | \$,MILLIONS | | | |
| CD=CDCER X (T X DF)XX(CDEXP) X CF | | | | 0.0 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X IF | | | | 241.032 | | | |
| CLRM = T / M | | | | 1.000 | | | |
| E = 1.0 + LOG(PHI) / LOG(2.0) | | | | 0.971 | | | |
| CTFU=(CLRM / E)X((16RM X Z1+.5)XX(E) -0.5XX(E)) | | | | 241.360 | | | |
| CTB =((CLRM/E)X((16RM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | |) / Z3 | | 232.000 | |
| CIPS=CTB*Z4/Z2 | | | | 0.0 | | | |
| CRCI =CTB X R | | | | 0.516 | | | |
| PRE-IOC CRCI =CRCI X Z6 | | | | 0.0 | | | |
| POST-IOC CRCI =CRCI X (1.0~Z6) | | | | 0.516 | | | |
| CUEM =UEM OR CTB*Z5/Z2/ENYR | | | | 0.516 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND OEM WERE 0.0 0.013734 0.0 | | | | | | | |
| SEE 1.2.1.1.17 FOR DDTE. 15 YEAR LIFE. PSM LOCATED ON SCB TO SUPPORT | | | | | | | |
| TFU MM8 ACTIVITIES. FOUR PSM'S (25) ON SCB TO SUPPORT SATELLITE OEM | | | | | | | |
| ACTIVITY FOR OPTION | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.2.3.1.4 POWER MODULE-PM

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|------------|------|----------------|--------------------|-----------|---------|-----|
| T= | 250.000000 | TF= | 1.000000 | CDCER= | 0.0 | | |
| M= | 250.000000 | UEM= | 0.0 | CDEXP= | 0.0 | | |
| Cf= | 1.000000 | Z1= | 2.000000 | CICER= | 1.287000 | | |
| PHI= | 0.980000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.006666 | Z3= | 24.000000 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 0.0 | 25= | 12.000000 | Z6= | 0.0 |
| CALCULATED VALUES | | KM | SUM TO 1.2.3.1 | \$,MILLIONS | | | |
| CD=CDCER X (T X DF)XX(CDEXP) X Cf | | | | 0.0 | | | |
| CLRM=CICER X (M)XX(CIEXP) X Cf X TF | | | | 321.750 | | | |
| IORM =T / M | | | | 1.000 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 0.971 | | | |
| CTFU=(CLRM / E)X(IORM X Z1+.5)XX(E) -0.5XX(E) | | | | 637.602 | | | |
| CTB =((CLRM/E)X(IORM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | |) / Z3 | | 301.152 | |
| CIPS=CTB*Z4/Z2 | | | | 0.0 | | | |
| CRC1 =CTB X R | | | | 2.007 | | | |
| PRE-IOC CRC1 =CRC1 X Z6 | | | | 0.0 | | | |
| POST-IOC CRC1 =CRC1 X (1.0-Z6) | | | | 2.007 | | | |
| CUEM =UEM OR CTB*Z5/Z2/ENYR | | | | 2.008 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND UEM WERE 0.0 1.100000 0.0 | | | | | | | |
| SEE 1.2.2.1.2 FOR DDTEE. 15 YEAR LIFE. PM ON SCB TO SUPPORT TFU MMB | | | | | | | |
| ACTIVITY WITH ONE LOCATED ONMMB. 4 ON SCB AND 8 ON MMB'S FOR SATELLITE | | | | | | | |
| OPTION | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.2.3.2.1 CRE HABITABILITY MODULE-CHM

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|------------|------|----------------|--------------------|----------|---------|-----|
| T= | 27000.0000 | TF= | 1.000000 | CDCER= | 0.0 | | |
| M= | 27000.0000 | OEM= | 0.0 | CDEXP= | 0.0 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.004411 | | |
| PHI= | 0.980000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.004444 | Z3= | 16.000000 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 0.0 | Z5= | 8.000000 | Z6= | 0.0 |
| CALCULATED VALUES | | KG | SUM TO 1.2.3.2 | \$.MILLIONS | | | |
| CU=CDCER X (T X DF)XX(CDEXP) X CF | | | | 0.0 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 119.094 | | | |
| ORM =T / M | | | | 1.000 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 0.971 | | | |
| CTFU=(CLRM / E)X(ORM X Z1+0.5)XX(E) -0.5XX(E)) | | | | 119.256 | | | |
| CTB =((CLRM/E)X(ORM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | |) / Z3 | | 112.666 | |
| CIPS=CTB*Z4/Z2 | | | | 0.0 | | | |
| CRCI =CTB X R | | | | 0.501 | | | |
| PRE-IDC CRCI =CRCI X Z6 | | | | 0.0 | | | |
| POST-IDC CRCI =CRCI X (1.0-Z6) | | | | 0.501 | | | |
| CUEM =OEM OR CT9*Z5/Z2/ENVR | | | | 0.501 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND OEM WERE 0.0 0.003770 0.0 | | | | | | | |
| SEE 1.2.2.2.1 FOR DOICE. 15 YEAR LIFE. CHM LOCATED ON NMB FOR TFU. | | | | | | | |
| 1 CHM ON EACH NMB TO SUPPORT OEM FOR OPTION | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.2.3.2.2 CONSUMABLES LOGISTICS MODULE-CLM

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|---|------------|------|----------------|--------------------|----------|-----|-----|
| T= | 5000.00000 | TF= | 1.000000 | CDCER= | 0.0 | | |
| M= | 5000.00000 | DEM= | 0.0 | CDEXP= | 0.0 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.016380 | | |
| PHI= | 0.980000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.004444 | Z3= | 16.000000 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 0.0 | Z5= | 8.000000 | Z6= | 0.0 |
| CALCULATED VALUES | | K6 | SUM TO 1.2.3.2 | \$,MILLIONS | | | |
| CD=CDCER X (1 X DF)XX(CDEXP) X CF | | | | 0.0 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 81.900 | | | |
| EORM =T / M | | | | 1.000 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 0.971 | | | |
| CTBU=(CLRM / E)X(1+EORM X Z1+0.5)XX(E) -0.5XX(E) | | | | 82.011 | | | |
| CTB =((CLRM/E)X(1+EORM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | |) / Z3 77.479 | | | |
| CIPS=CTB*Z4/Z2 | | | | 0.0 | | | |
| CRC1 =CTB X R | | | | 0.344 | | | |
| PRE-10C CRC1 =CRC1 X Z6 | | | | 0.0 | | | |
| POST-10C CRC1 =CRC1 X (1.0-Z6) | | | | 0.344 | | | |
| LOGM =DEM OR CTB*Z5/Z2/ENVR | | | | 0.344 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND DEM WERE 0.0 0.014000 0.0 | | | | | | | |
| SEE 1.2.2.2.2 FOR DD16E. 15 YEAR LIFE. CLM LOCATED ON MM8 | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.2.3.3.1 SATELLITE OPERATIONS CREW - SCB

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|---|----------|--------|----------------|--------------------|------------|-------|-----|
| T= | 8.000000 | TF= | 1.000000 | CDCER= | 0.0 | | |
| M= | 1.000000 | LEM= | 0.0 | CDEXP= | 0.0 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.073008 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.0 | Z3= | 120.000000 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 0.0 | Z5= | 120.000000 | Z6= | 0.0 |
| CALCULATED VALUES | | PERSON | SUM TO 1.2.3.3 | \$,MILLIONS | | | |
| CD=CDCER X (T X DF)X(CDEXP) X CF | | | | 0.0 | | | |
| CLRM=CICER X (M)X(CIEXP) X CF X TF | | | | 0.073 | | | |
| BPRM =T / M | | | | 8.000 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 1.000 | | | |
| CTFU=(CLRM / E)X((BPRM X Z1+0.5)X(E) -0.5X(E)) | | | | 0.584 | | | |
| CTB =((CLRM/E)X((BPRM X Z3 + 0.5)X(E) -0.5X(E)) | | | |) / Z3 | | 0.584 | |
| CIPS=CTB*Z4/Z2 | | | | 0.0 | | | |
| CRC1 =CTB X R | | | | 0.0 | | | |
| PRE-IOC CRC1 =CRC1 X Z6 | | | | 0.0 | | | |
| POST-IOC CRC1 =CRC1 X (1.0-Z6) | | | | 0.0 | | | |
| COGM =LEM OR CTB*Z5/Z2/ENYR | | | | 0.039 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND OGM WERE 0.0 0.062400 0.0 | | | | | | | |
| 8 PERSON CREW STATIONED ON SCB FOR TYP. CREW SERVICES 2 MOBILE | | | | | | | |
| MAINTENANCE BASES (MMBS). NO SATELLITE OPTION REQUIRES 4 SCB CREWS. | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.2.3.3.2 SATELLITE OPERATIONS CREW - MMB

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | | |
|---|-----------|---------|----------------|--------------------|------------|-----|-----|-------|
| T= | 30.000000 | TF= | 1.000000 | CDCER= | 0.0 | | | |
| M= | 1.000000 | UEM= | 0.0 | CDEXP= | 0.0 | | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.073008 | | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | | |
| R= | 0.0 | Z3= | 240.000000 | BYEAR= | 1979 | | | |
| DF= | 1.000000 | Z4= | 0.0 | Z5= | 240.000000 | Z6= | 0.0 | |
| CALCULATED VALUES | | PERSONS | SUM TO 1.2.3.3 | \$, MILLIONS | | | | |
| CD=CDCER X (T X DF)XX(CDEXP) X CF | | | | 0.0 | | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 0.073 | | | | |
| E = T / M | | | | 30.000 | | | | |
| E = 1.0 + LOG(PHI) / LOG(2.0) | | | | 1.000 | | | | |
| CTFU=(CLRM / E)X((E X Z1 + 0.5)XX(E) - 0.5XX(E)) | | | | 2.190 | | | | |
| CTB = ((CLRM/E)X((E X Z3 + 0.5)XX(E) - 0.5XX(E)) | | | | 1 / Z3 | | | | 2.190 |
| CIPS=CIB*Z4/Z2 | | | | 0.0 | | | | |
| CRC1 = CTB X R | | | | 0.0 | | | | |
| PRE-IDC CRC1 =CRC1 X Z6 | | | | 0.0 | | | | |
| POST-IDC CRC1 =CRC1 X (1.0-Z6) | | | | 0.0 | | | | |
| CUEM =UEM OR CTB*Z5/Z2/ENYR | | | | 0.292 | | | | |
| COMMENTS | | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND UEM WERE 0.0 0.062400 0.0 | | | | | | | | |
| 30 PERSON CREW ON EACH MOBILE MAINTENANCE BASE (MMB) ONE MMB SERVICES | | | | | | | | |
| 2 SATELLITES EVERY 90 DAYS ON THE AVERAGE. 2MMBS REQUIRED FOR | | | | | | | | |
| OPERATIONS OVER TERM | | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.2.3.3.3 CREW PROVISIONS - SCB

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|---|------------|------|----------------|--------------------|------------|-----|-----|
| T= | 10368.0000 | TF= | 1.000000 | CDCER= | 0.0 | | |
| M= | 1.000000 | DEM= | 0.0 | CDEXP= | 0.0 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.000026 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.0 | Z3= | 120.000000 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 0.0 | Z5= | 120.000000 | Z6= | 0.0 |
| CALCULATED VALUES | | CREW | SUM TO 1.2.3.3 | \$ MILLIONS | | | |
| CD=CDCER X (T X DF)XX(CDEXP) X CF | | | | 0.0 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 0.000 | | | |
| EORM =T / M | | | | 10368.000 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 1.000 | | | |
| CTFU=(CLRM / E)X(EORM X Z1+0.5)XX(E) -0.5XX(E)) | | | | 0.267 | | | |
| CTB =((CLRM/E)X(EORM X Z3 + 0.5)XX(E) -0.5XX(E)) | | |) / Z3 | 0.267 | | | |
| CIPS=CTB*24/22 | | | | 0.0 | | | |
| CRC1 =CTB X R | | | | 0.0 | | | |
| PRE-IOC CRC1 =CRC1 X Z6 | | | | 0.0 | | | |
| POST-IOC CRC1 =CRC1 X (1.0-Z6) | | | | 0.0 | | | |
| COEM =DEM OR CTR*25/22/ENYR | | | | 0.018 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND DEM WERE 0.0 0.000022 0.0 | | | | | | | |
| \$26/KG AT 3.6 KG/PERSON/DAY. 9 PERSON CREW AT SCB PER 16 SATELLITES. | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.2.3.3.4 O&M CREW PROVISIONS - MMB

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|---|------------|------|----------------|--------------------|--------------|-----|-----|
| T= | 38880.0000 | TF= | 1.000000 | CDCER= | 0.0 | | |
| M= | 1.000000 | UEM= | 0.0 | COEXP= | 0.0 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.000026 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.0 | Z3= | 240.000000 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 0.0 | Z5= | 240.000000 | Z6= | 0.0 |
| CALCULATED VALUES | | CREW | SUM TO 1.2.3.3 | | \$, MILLIONS | | |
| CD=CDCER X (T X DF)XX(COEXP) X CF | | | | | 0.0 | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | | 0.000 | | |
| ORM = T / M | | | | | 38880.000 | | |
| E = 1.0 + LOG(PHI) / LOG(2.0) | | | | | 1.000 | | |
| CIFU=(CLRM / E)X((ORM X Z1+0.5)XX(E) -0.5XX(E)) | | | | | 1.001 | | |
| CTB = ((CLRM/E)X((ORM X Z3 + 0.5)XX(E) -0.5XX(E)) | | |) / Z3 | | 1.001 | | |
| CIPS=CTB*Z4/Z2 | | | | | 0.0 | | |
| CRC1 =CTB X R | | | | | 0.0 | | |
| PRE-10C CRC1 =CRC1 X Z6 | | | | | 0.0 | | |
| POST-10C CRC1 =CRC1 X (1.0-Z6) | | | | | 0.0 | | |
| CO&M =O&M OR C1B*Z5/Z2/ENYR | | | | | 0.133 | | |

COMMENTS

1977 DATA ENTERED FOR CDCER, CICER, AND UEM WERE 0.0 0.000022 0.0
\$26/KG AT 3.6 KG/PERSON/DAY. 30 PERSON CREW ON EACH MMB. MMB SERVICES
2 SATELLITES EVERY 90 DAYS ON THE AVERAGE. OPTION REQUIRES SERVICES FOR
8 MMB'S.

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1.3 TRANSPORTATION

This element of the SPS program covers all space transportation system vehicle and operational requirements needed to accommodate the delivery of materials and personnel to orbit. The requirement supports SPS satellite system fabrication, assembly, test and evaluation plus the replacement and operations/maintenance of space systems. Estimates of cost and cost analyses in this section cover transportation systems used to transfer materials and personnel to LEO, LEO to GEO, and within LEO and GEO orbits during space construction and lifetime operation of the satellite system.

Figure 1.3-1 illustrates the Rockwell reference transportation flight operations scenario designed to deliver cargo and personnel to geosynchronous (GEO) orbit for SPS construction. Three SPS unique elements of the system are: the Heavy Lift Launch Vehicle (HLLV), the Electric Orbit Transfer Vehicle (EOTV), and the Personnel Orbit Transfer Vehicle (POTV). The HLLV is a two stage parallel burn launch vehicle utilizing LOX/RP in the first stage and LOX/LH₂ in the second stage. Second stage propellants are crossfed from the first stage during first stage burn. These stages take off from a vertical position and land horizontally in a manner similar to that of the Shuttle transportation system. Each HLLV launch can transport a 0.227×10^6 kg (0.500×10^6 lb) payload to low earth orbit (LEO).

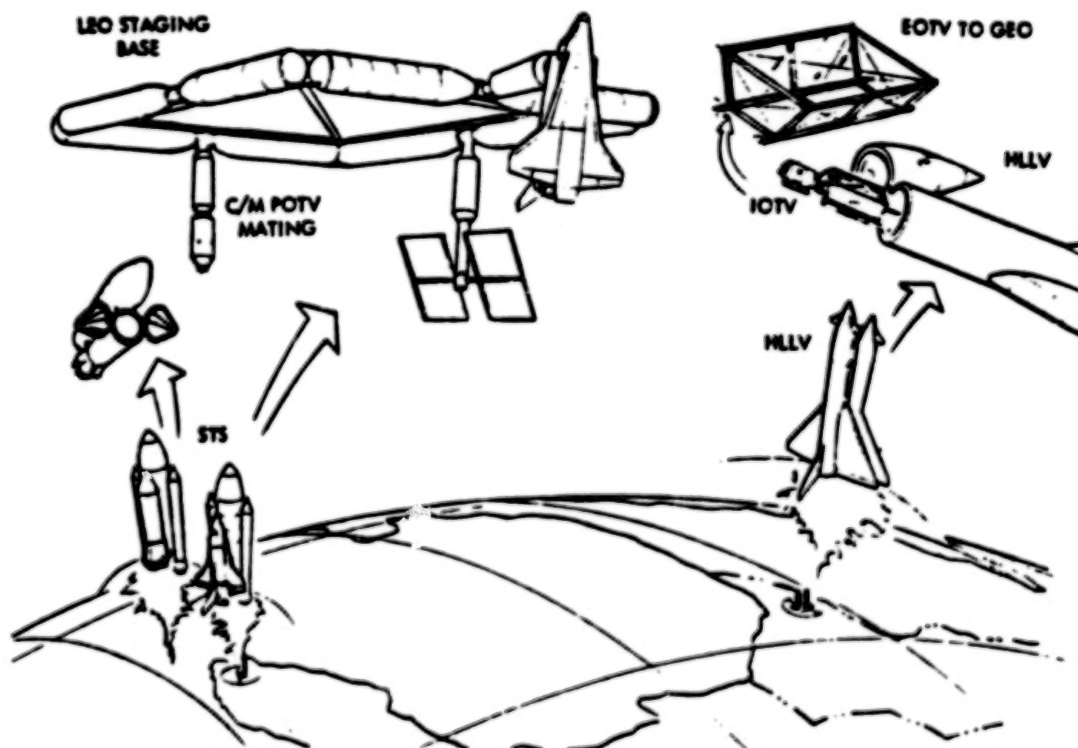


Figure 1.3-1. SPS Transportation System—LEO Operations Operational Program

The second major transportation element is the LEO-to-GEO cargo transfer vehicle, the EOTV. The EOTV consists of a basic solar array structure and electric (ion) thruster arrays by which as much as 6.86 10³ kg of cargo can be transferred to a GEO—located construction site. A maximum EOTV load would therefore accommodate approximately 25 HLLV missions. The same EOTV configuration has been retained for all satellite options.

A third vehicle is designed to transport personnel from the LEO staging area to and from the GEO site. The vehicle consists of a single chemical propulsion stage and a separable crew module. The propulsion element is refueled in GEO for return to LEO. Acceleration and operation restrictions are similar to those imposed for manned space vehicles.

Transportation requirements and concepts for SPS vary as a function of program phase. During the research/technology phase (1981-1987), the baseline Space Shuttle is planned to conduct sortie missions. Its use will continue through the period of space activities to prove the concept by ultimate construction of a pilot power plant. A growth vehicle will use solid rocket boosters to transfer personnel to orbit in preparation for LEO base and SPS construction base facilities. An STS derivative vehicle will consist of a solid rocket booster and a special payload/engine module (replacing the orbiter) to serve as a cargo carrier. The SPS VTO/HL HLLV is scheduled later in the program for use in EOTV construction and SPS fabrication/operations.

During satellite construction phases, geosynchronous orbit is the eventual destination of SPS construction materials/equipment, personnel, and supplies. The crews will be transported from earth to LEO by the SPS VTO/HL HLLV containing the personnel module (PM) where the PM will then be carried to GEO by the POTV. Cargo will be delivered to LEO by the SPS VTO/HL-HLLV configuration, transferred to the EOTV by IOTV's, transported to GEO by the EOTV, and off-loaded by IOTV's. Additional detail on the individual vehicles is presented in later subsections.

Mass-to-orbit cost requirements for construction, propellant, and operations/maintenance activities were established in accordance with the mission profile and build schedule of required SPS satellite options with a first unit (TFU) by the end of year 2000. These calculations are based on a round trip vehicle life as shown in Table 1.3-1.

Vehicle flight and fleet requirements to build the first (TFU) Rockwell SPS reference configuration satellite are identified in Table 1.3-2. These calculations were based on the mass to LEO and to GEO for personnel, materials, and supplies needed to construct the satellite and EOTV vehicle reflecting mission timelines, turnaround schedules, and flight profiles.

Transportation vehicle and flight requirements for the Rockwell reference configuration are identified in Table 1.3-3 by construction (Pre-IOC) and operation and maintenance (Post-IOC) categories. These elements of the traffic model were used in calculations of costs associated with fleet requirements for a 60-unit SPS program.

Table 1.3-1. Vehicle Life with Maintenance

| VEHICLE | R.T. FLIGHTS PER VEHICLE |
|--|-----------------------------|
| SPS VTO/HL HEAVY LIFT LAUNCH VEHICLE (500,000 lb, 227,000 kg) | 300 |
| EOTV CARGO (ELECTRIC) ORBIT TRANSFER VEHICLE | 20 |
| POTV PERSONNEL ORBIT TRANSFER VEHICLE | 100 |
| IOTV INTRA-ORBIT TRANSFER VEHICLE | 200 |

Table 1.3-2. GaAs Reference SPS Concept—TFU Transportation Requirements

| | VEHICLE FLIGHTS | | | | | |
|---------------------------------|-----------------|-------|------|------|------|-----|
| | PLV (HLLV) | HLLV | POTV | EOTV | IOTV | |
| | | | | | LEO | GEO |
| SATELLITE CONSTRUCTION & MAINT. | 5.4 | 153.3 | 40 | 5.1 | 215 | 153 |
| CREW CONSUMABLES | | 6.6 | | - | 7 | - |
| POTV PROPELLANTS | | 12.7 | | 0.2 | 13 | 6 |
| EOTV CONSTRUCTION & MAINTENANCE | | 32.8 | | - | 33 | - |
| EOTV PROPELLANTS | | 33.5 | | - | 34 | - |
| IOTV PROPELLANTS | | 0.6 | | - | 1 | 1 |
| SCB TO GEO | | - | | 2 | - | - |
| TOTAL FLIGHTS | 5 | 240 | 40 | 8 | 303 | 160 |
| FLEET | - | 5 | 4 | 6 | 2 | 2 |

Table 1.3-3. GaAs Reference SPS Concept—Total Transportation Requirements (60 Satellites)

| | MASS $\times 10^6$ kg | | VEHICLE FLIGHTS | | | | | |
|-------------------|-----------------------|--------|-----------------|--------|------|-------|--------|--------|
| | LEO | GEO | PLV (HLLV) | HLLV | POTV | EOTV | IOTV | |
| | | | | | | | LEO | GEO |
| SATELLITE | | | | | | | | |
| CONSTRUCTION | 2087.7 | 2087.7 | 111 | 9,197 | 1220 | 306.4 | 10,741 | 9,197 |
| OPS & MAINT. | 492.2 | 492.2 | 34 | 2,168 | 324 | 72.7 | 2,560 | 2,168 |
| CREW CONSUMABLES | | | | | | | | |
| CONSTRUCTION | 29.9 | 28.7 | | 132 | | 4.2 | 132 | 126 |
| OPS & MAINT. | 9.2 | 7.6 | | 41 | | 1.1 | 41 | 34 |
| POTV PROPELLANTS | | | | | | | | |
| CONSTRUCTION | 87.9 | 44.0 | | 387 | | 6.5 | 387 | 194 |
| OPS & MAINT. | 23.3 | 11.7 | | 103 | | 1.7 | 103 | 52 |
| EOTV CONSTRUCTION | | | | | | | | |
| CONSTRUCTION | 19.9 | 12.4 | | 88 | | 1.8 | 88 | 55 |
| OPS & MAINT. | 5.0 | 5.0 | | 22 | | 0.7 | 22 | 22 |
| EOTV PROPELLANTS | | | | | | | | |
| CONSTRUCTION | 306.0 | 1.9 | | 1,348 | | 0.3 | 1,348 | 8 |
| OPS & MAINT. | 73.0 | 0.8 | | 322 | | 0.1 | 322 | 4 |
| IOTV PROPELLANTS | | | | | | | | |
| CONSTRUCTION | 7.4 | 3.2 | | 33 | | 0.5 | 33 | 14 |
| OPS & MAINT. | 1.8 | 0.8 | | 8 | | 0.1 | 8 | 3 |
| SUMMARY | | | | | | | | |
| CONSTRUCTION | 2538.8 | 2177.9 | 111 | 11,185 | 1220 | 320 | 12,729 | 9,594 |
| OPS & MAINT. | 604.5 | 518.1 | 34 | 2,664 | 324 | 76 | 3,056 | 2,283 |
| TOTAL | 3143.3 | 2696.0 | 145 | 13,849 | 1544 | 396 | 15,785 | 11,877 |
| VEHICLE FLEET | | | | | | | | |
| CONSTRUCTION | - | - | - | 38 | 12 | 16 | 112 | |
| OPS & MAINT. | - | - | - | 9 | 3 | 4 | 27 | |
| TOTAL | - | - | - | 47 | 15 | 20 | 139 | |

1.3.1 SPS HEAVY-LIFT LAUNCH VEHICLE

The SPS HLLV is shown in Figure 1.3-2 and has a payload capability of 227,000 kg with a vertical takeoff and horizontal landing feature. The SPS HLLV is used to bring space construction and support equipment payloads, satellite system hardware, OTVs, consumables and crew expendables, and propellants from earth to LEO. This element covers SPS HLLV vehicles and operations required to support satellite system assembly and operation during a 30-year period. Ground rules and guidelines applicable to the HLLV are summarized in Table 1.3-4.

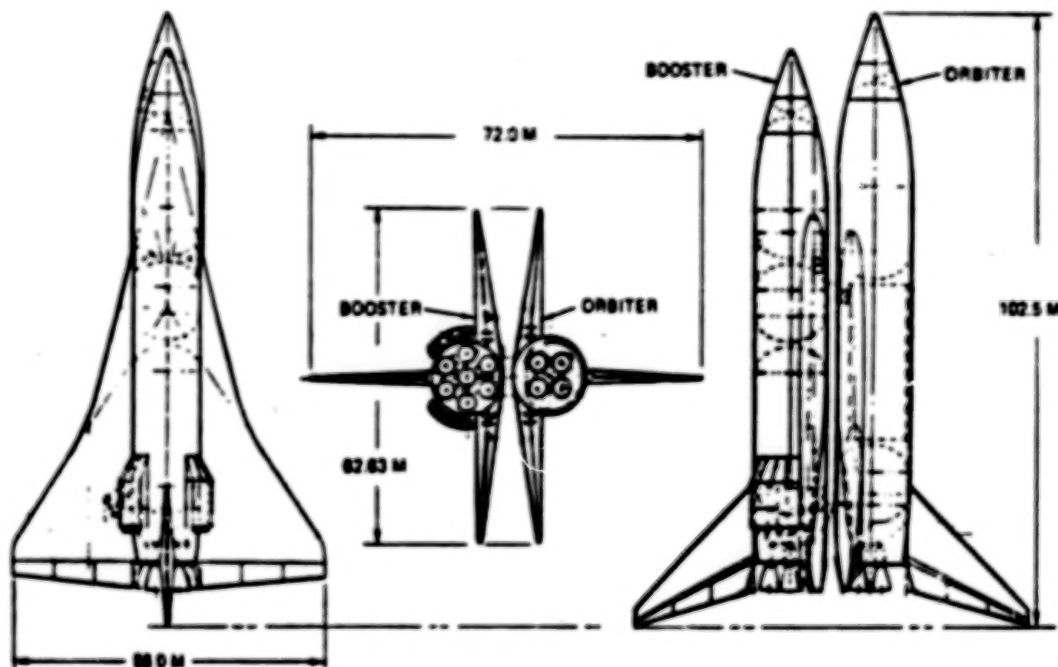


Figure 1.3-2. SPS VTO/VL HLLV System Launch Configuration

1.3.1.1 SPS HLLV FLEET

A total of 47 HLLV vehicles are required to handle mass flow requirements throughout the 60-year SPS program; Thirty-eight vehicle are required for the construction of 60 satellites and 9 vehicles are needed for operation and maintenance during the 30-year satellite lifetime.

Data used in projecting estimates for the HLLV were factored from the NASA/JSC Contract NAS9-15196. Specific changes were made to consider the reference HLLV design configuration: vehicle complexity factors—engines, ablative shield, propellant valves, and system/subsystem design; and the greater mass of the orbiter/booster as compared with current experience and Rockwell Space Shuttle contract work.

Table 1.3-4. HLLV Ground Rules/Assumptions

- Two-stage vertical takeoff/horizontal landing (VTO/HL)
- Flyback capability both stages; ABES, first stage only
- Parallel burn with propellant crossfeed
- LOX/EP first stage; LOX/LH₂ second stage
- High P_c gas generator cycle engine; 1st stage [I_s (VAC) = 352 sec.]
- High P_c staged combustion engine; 2nd stage [I_s (VAC) = 466 sec.]
- Staging velocity—heat sink booster compatible
- Circa 1990 technology base—BAC/MMC weight reduction data
- Orbital parameters—487 km @ 31.6°
- Payload capability—227×10³ kg up/45 kg down
- Thrust/weight—1.30 liftoff/3.0 max.
- 15% weight growth allowance/0.75% ΔV margin

HLLV capital asset replacements, major overhaul requirements, spares provisioning, and system lifetimes were projected as being the equivalent of 1.5 vehicle replacements for each of the SPS fleet vehicles. These calculations amount to a total of 71 RCI vehicle equivalents with an allocation of approximately 57 to pre-IOC activities associated with satellite construction, and about 14 HLLV equivalents chargeable to the O&M activity after IOC.

See Table 1.3.1.1 for SPS HLLV cost computer program tabulations.

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.3.1.1 SPS-HLLV FLEET

INPUT PARAMETERS

INPUT COEFFICIENTS

| | | | | | |
|------|----------|------|------------|--------|------------|
| T= | 1.000000 | TF= | 1.000000 | CDCER= | 10062.0000 |
| M= | 1.000000 | UGM= | 0.0 | CDEXP= | 1.000000 |
| CF= | 1.000000 | Z1= | 5.000000 | CICER= | 2340.00000 |
| PHI= | 0.950000 | Z2= | 60.000000 | CIEXP= | 1.000000 |
| R= | 0.039444 | Z3= | 118.000000 | BYEAR= | 1979 |
| DF= | 1.000000 | Z4= | 38.000000 | Z5= | 9.000000 |
| | | | | Z6= | 0.808510 |

CALCULATED VALUES

SET

SUM TO 1.3.1

\$, MILLIONS

CD=CDCER X (T X DF)XX(CDEXP) X CF 10062.000

CLRM=CICER X (M)XX(CIEXP) X CF X TF 2340.000

BRM = T / M 1.000

E = 1.0 + LOG(PHI) / LOG(2.0) 0.926

CIFU=(CLRM / E)X((BRM X Z1+0.5)XX(E) -0.5XX(E)) 10921.242

CTB =((CLRM/E)X((BRM X Z3 + 0.5)XX(E) -0.5XX(E))) / Z3 1771.045

CIPS=CTB*Z4/Z2 1121.661

CRCI =CTB X R 69.857

PRE-IOC CRCI =CRCI X Z6 56.480

POST-IOC CRCI =CRCI X (1.0-Z6) 13.377

COEM =UGM OR CTB*Z5/Z2/E/HR 8.855

COMMENTS

1977 DATA ENTERED FOR CDCER, CICER, AND UGM WERE 8600.00000 2000.00000 0.0

118 VEHICLES IN FLEET=71 RC1, 38 CONSTR RELATED, 9 OEM RELATED RC1 AT

1.5 VEHICLE EQUIVALENTS TO KEEP HLLV OPERATIONAL

1.3.1.2 SPS HLLV OPERATIONS

This element includes necessary vehicle operations (user charge per flight including payload integration) required to support the SPS program. The HLLV has a lifetime capability of 300 flights.

There is a total of 13,849 roundtrip flights required to support the 60-year program, where approximately 227,000 kg is delivered per flight. These are grouped into a total of 11,185 flights for construction and 2664 flights for operations and maintenance. The TFU requires a total of 245 flights to carry the necessary mass to orbit. On the average of 60 satellites, approximately 186 flights are needed for satellite construction and 44 flights are required for operations and maintenance per satellite over the 30-year operational period.

The projected cost per HLLV flight is based on contract data (reference NAS9-15196) that was factored and revised to arrive at a propellant, payload integration, and supporting operational cost by evaluation against such things as propellant costs versus HLLV requirements. See Table 1.3.1.2.

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.3.1.2 SPS-HLLV OPERATIONS (VTD-HL)

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|----------|--------|--------------|--------------------|------------|-----|----------|
| T= | 1.000000 | TF= | 1.000000 | CDCER= | 0.0 | | |
| M= | 1.000000 | UEM= | 0.0 | CDEXP= | 0.0 | | |
| CF= | 1.000000 | Z1= | 245.000000 | CICER= | 2.901599 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.0 | Z3= | 13849.0000 | BVEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 11185.0000 | Z5= | 2664.00000 | Z6= | 0.807640 |
| CALCULATED VALUES | | FLIGHT | SUM TO 1.3.1 | \$, MILLIONS | | | |
| CD=CDCER X (T X DF)XX(CDEXP) X CF | | | | 0.0 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 2.902 | | | |
| ORM = T / M | | | | 1.000 | | | |
| E = 1.0 + LOG(PHI) / LOG(2.0) | | | | 1.000 | | | |
| CTFU=(CLRM / E)X(ORM X Z1+0.5)XX(E) -0.5XX(E) | | | | 710.892 | | | |
| CTB =(1CLRM/E)X(ORM X Z3 + 0.5)XX(E) -0.5XX(E) | | | | 2.902 | | | |
| CIPS=CTB*Z4/Z2 | | | | 540.906 | | | |
| CRC1 =CTB X R | | | | 0.0 | | | |
| PRE-IDC CRC1 =CRC1 X Z6 | | | | 0.0 | | | |
| POST-IDC CRC1 =CRC1 X (1.0-Z6) | | | | 0.0 | | | |
| CUEM =UEM OR CTB*Z5/Z2/ENVR | | | | 4.294 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND UEM WERE | | | | 0.0 | 2.480000 | 0.0 | |

1.3.2 CARGO ORBITAL TRANSFER VEHICLE (COTV)

This element includes the COTV vehicle and operations required to support satellite system assembly and operation. Included is the LEO-to-GEO transfer of space construction and support equipment, satellite system hardware, spares, and propellants required throughout satellite lifetime, plus O&M materials.

An electric orbital transfer vehicle (EOTV) is employed as the primary transportation element for SPS cargo from LEO to GEO. The vehicle configuration defined to accomplish this mission phase has a high specific impulse thruster that utilizes the same power source and construction techniques as the SPS. The concept is shown in Figure 1.3-3 and has a payload capability of 6.814×10^6 kg (equivalent to 30 HLLV payloads) with a six-month roundtrip time per flight. The solar array consists of two "bays" of the SPS, electric argon-ion engine arrays, and the requisite propellant storage and power conditioning equipment. The vehicle configuration, payload capability, and "trip time" have been established on the basis of expected overall SPS performance characteristics.

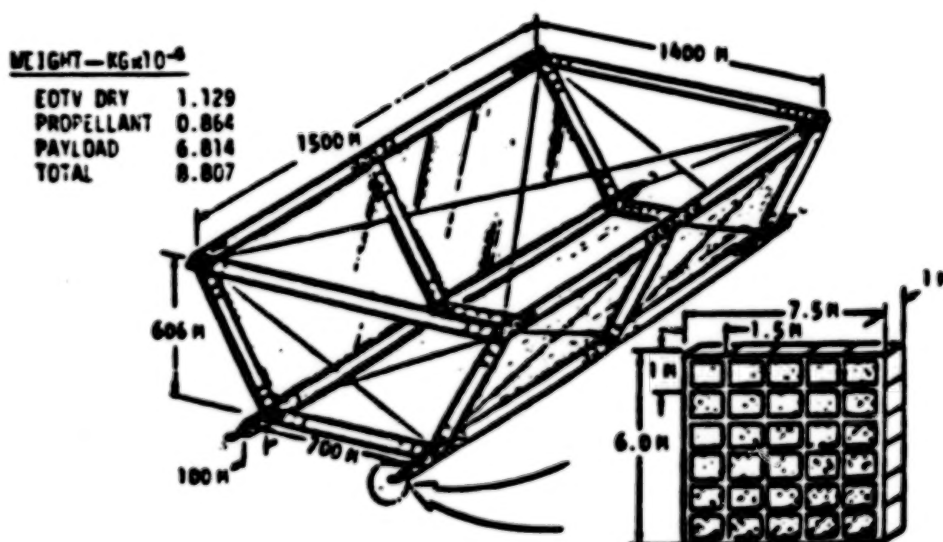


Figure 1.3-3. Rockwell EOTV Reference Update—1980

COTV fleet procurement and operations are detailed in Sections 1.3.2.1 and 1.3.2.2, respectively.

1.3.2.1 COTV FLEET

This element of the WBS covers COTV fleet requirements in support of construction and operational phases of the SPS program. The COTV structural configuration is equivalent to the design/profile of a satellite bay except it is equipped with thruster arrays and an attitude control system. It has a dry weight of 903,000 kg with subsystem masses as shown in Table 1.3-5.

Table 1.3-5. EOTV Weight Summary (GaAs)

| ITEM DESCRIPTION | SUBTOTAL MASS (kg×10 ⁶) | TOTAL MASS (kg×10 ⁶) |
|---|---|--|
| STRUCTURE | | 0.106 |
| PRIMARY STRUCTURE | 0.041 | |
| SECONDARY STRUCTURE | 0.056 | |
| MECHANISMS | 0.006 | |
| TRACKS AND ACCESSWAYS | 0.003 | |
| SOLAR BLANKETS (949,000 m ²) | | 0.229 |
| CONCENTRATORS (1,823,200 m ²) | | 0.033 |
| POWER DISTRIBUTION & CONDITIONING | | 0.422 |
| SWITCH GEAR & REGULATORS | 0.0027 | |
| LOW-VOLTAGE CONVERTERS | 0.0003 | |
| CONDUCTORS AND INSULATION | 0.265 | |
| BATTERIES (INCL. ACS REQMTS) | 0.152 | |
| BATTERY PD&C (INCL. ACS REQMTS) | 0.002 | |
| PROPULSION & ACS SYSTEM | | 0.111 |
| ACS HARDWARE | | |
| THRUSTERS (120), 1 m × 1.5 m | 0.022 | |
| TANKS & PROPELLANT LINES | 0.086 | |
| ATTITUDE REF. SYSTEM | 0.001 | |
| POWER PROCESSING EQUIPMENT | 0.002 | |
| INFORMATION MANAGEMENT | | <u>0.002</u> |
| GRAND TOTAL | | 0.903 |
| WITH 25% GROWTH | | 1.129 |
| ARGON PROPELLANT PER EOTV R.T. FLIGHT | | 0.864 |

The thruster array consists of 1.0 m by 1.5 m rectangular thrusters at four locations. A specific impulse of 7900/second results in a high thrust capable of handling large payloads for the array power output. The total attitude control system and thruster array mass is equal to 119,000 kg (dry) per EOTV (Table 1.3-6).

Table 1.3-6. EOTV ACS Mass Summary

| ITEM DESCRIPTION | MASS (kg) |
|---------------------------------------|--------------|
| THRUSTERS (120) 1 METER BY 1.5 METERS | 22,000 |
| PROPELLANT TANKS AND LINES | 86,000 |
| ACS CONDUCTORS & INSULATION | 6,000 |
| ATTITUDE REFERENCE SYSTEM | 1,000 |
| THRUSTER GIMBALS AND MOUNTING | 2,000 |
| POWER PROCESSING EQUIPMENT | 2,000 |
| TOTAL (DRY) | 119,000 |
| PROPELLANT (ARGON) | 864,000 |

EOTV cost estimates were developed from those of the main satellite because of design and system similarities. Adjustment factors for development and learning were used to reflect the period of time and technology state of these requirements versus those for the satellite in coming years. Replacement capital investment factors were calculated on the average of a 5-6% vehicle attrition. Table 1.3-7 identifies COTV elements/systems costed.

Table 1.3-7. EOTV Cost Elements

| <u>WBS Element</u> | <u>Description</u> |
|--------------------|------------------------------------|
| 1.3.2.1.1 | Primary Structure |
| 1.3.2.1.2 | Secondary Structure |
| 1.3.2.1.3 | Mechanisms |
| 1.3.2.1.4 | Tracks and Access Ways |
| 1.3.2.1.5 | Concentrator |
| 1.3.2.1.6 | Solar Blanket |
| 1.3.2.1.7 | Switch Gear and Regulators |
| 1.3.2.1.8 | Low-Voltage Converters |
| 1.3.2.1.9 | Conductors and Insulation |
| 1.3.2.1.10 | Batteries |
| 1.3.2.1.11 | Battery PD&C |
| 1.3.2.1.12 | ACS Hardware—COTV |
| 1.3.2.1.13 | Information Management and Control |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.3.2.1.1 PRIMARY STRUCTURE

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|------------|------|----------------|--------------------|----------|-------|----------|
| T= | 41000.0000 | TF= | 1.000000 | CDCER= | 0.026910 | | |
| M= | 15.000000 | UEM= | 0.0 | CDEXP= | 0.800000 | | |
| CF= | 1.000000 | Z1= | 6.000000 | CICER= | 0.000058 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.0 | Z3= | 20.000000 | BYEAR= | 1979 | | |
| DF= | 0.050000 | Z4= | 16.000000 | Z5= | 4.000000 | Z6= | 0.800000 |
| CALCULATED VALUES | | KG | SUM TO 1.3.2.1 | \$, MILLIONS | | | |
| CU=CDCER X (T X DF)XX(CDEXP) X LF | | | | 12.004 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 0.001 | | | |
| ORM = T / M | | | | 2733.333 | | | |
| E = 1.0 + LOG(PHI) / LOG(2.0) | | | | 1.000 | | | |
| CTFU=(CLRM / E)X(ORM X Z1+.5)XX(E) -0.5XX(E) | | | | 14.391 | | | |
| CTB =((CLRM/E)X(ORM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | | 1 / Z3 | | 2.398 | |
| CIPS=CTB*Z4/Z2 | | | | 0.640 | | | |
| CRCI =CTB X R | | | | 0.0 | | | |
| PRE-IOC CRCI =CRCI X Z6 | | | | 0.0 | | | |
| POST-IOC CRCI =CRCI X (1.0-Z6) | | | | 0.0 | | | |
| COEM =OEM OR CTR*Z5/Z2/EMR | | | | 0.005 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND OEM WERE 0.023000 0.000050 0.0 | | | | | | | |
| COMPOSITE MATERIAL. 20 EUTV FLEET. 16 FOR CONSTRUCTION. 4 FOR OEM | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.3.2.1.2 SECONDARY STRUCTURE

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|---|------------|------|----------------|--------------------|----------|--------|----------|
| T= | 56000.0000 | TF= | 0.038263 | CDLER= | 0.182520 | | |
| M= | 5.000000 | LEM= | 0.0 | CDEXP= | 0.511000 | | |
| CF= | 0.800000 | Z1= | 6.000000 | CICER= | 0.118170 | | |
| PHI= | 0.980000 | Z2= | 60.000000 | CIEXP= | 0.355000 | | |
| R= | 0.001111 | Z3= | 22.000000 | BYEAR= | 1979 | | |
| DF= | 0.100000 | Z4= | 16.000000 | Z5= | 4.000000 | Z6= | 0.800000 |
| CALCULATED VALUES | | KG | SUM TO 1.3.2.1 | \$, MILLIONS | | | |
| CD=CDLER X (T X DF)XX(CDEXP) X CF | | | | 12.015 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 0.006 | | | |
| FORM = T / M | | | | 11200.000 | | | |
| E = 1.0 + LOG(PHI) / LOG(2.0) | | | | 0.971 | | | |
| CTFU=(CLRM / E)X((FORM X Z1+.5)XX(E) -0.5XX(E)) | | | | 320.645 | | | |
| CTB =((CLRM/E)X((FORM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | | 1 / Z3 | | 51.455 | |
| CIPS=CTB*Z4/Z2 | | | | 13.721 | | | |
| CRC1 =CTB X R | | | | 0.057 | | | |
| PRE-IOC CRC1 =CRC1 X Z6 | | | | 0.046 | | | |
| POST-IOC CRC1 =CRC1 X (1.0-Z6) | | | | 0.011 | | | |
| OCM =OCM OR CTR*Z5/Z2/ENVR | | | | 0.114 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDLER, CICER, AND OCM WERE 0.156000 0.101000 0.0 | | | | | | | |
| INCLUDES THRUSTER STRUCTURE (2000 KG) IN ADDITION TO EOTV BAY SECONDARY | | | | | | | |
| STRUCTURE NEEDS. | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.3.2.1.3 MECHANISMS - EDTV

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|------------|------|----------------|--------------------|----------|-----|----------|
| T= | 6000.00000 | TF= | 1.000000 | CDCER= | 0.182520 | | |
| M= | 110.000000 | DEM= | 0.0 | CDEXP= | 0.511000 | | |
| CF= | 1.000000 | Z1= | 6.000000 | CICER= | 0.000894 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 0.950000 | | |
| R= | 0.0 | Z3= | 20.000000 | BYEAR= | 1979 | | |
| DF= | 0.300000 | Z4= | 16.000000 | Z5= | 4.000000 | Z6= | 0.800000 |
| CALCULATED VALUES | | AG | SUM TO 1.3.2.1 | \$, MILLIONS | | | |
| LD=CDCER X (T X DF)XX(CDEXP) X CF | | | | | | | 8.409 |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | | | | 0.078 |
| 60240 ORM = T / M | | | | | | | 54.545 |
| E = 1.0 + LOG(PHI) / LOG(2.0) | | | | | | | 1.000 |
| CTFU=(CLRM / E)X((ORM X Z1+0.5)XX(E) -0.5XX(E)) | | | | | | | 25.440 |
| CTB = ((CLRM/E)X((ORM X Z3 + 0.5)XX(E) -0.5XX(E))) / Z3 | | | | | | | 4.240 |
| LIPS=CTB*Z4/Z2 | | | | | | | 1.131 |
| CRCI =CTB X R | | | | | | | 0.0 |
| PRE-IUC CRCI =CRCI X Z6 | | | | | | | 0.0 |
| POST-IUC CRCI =CRCI X (1.0-Z6) | | | | | | | 0.0 |
| COEM =DEM OR CTR*Z5/Z2/ENYR | | | | | | | 0.009 |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND DEM WERE | | | | 0.156000 | 0.000764 | 0.0 | |
| TENSION DEVICES, PAYLOAD LATCHES, THRUSTER GIMBALS | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.3.2.1.4 TRACKS AND ACCESSWAYS

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|---|------------|------|----------------|--------------------|----------|-----|----------|
| T= | 3000.00000 | TF= | 1.000000 | CDCER= | 0.0 | | |
| M= | 100.000000 | LEM= | 0.0 | CDEXP= | 0.0 | | |
| CF= | 1.000000 | Z1= | 6.000000 | CICER= | 0.000058 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.0 | Z3= | 20.000000 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 16.000000 | Z5= | 4.000000 | Z6= | 0.800000 |
| CALCULATED VALUES | | K6 | SUM TO 1.3.2.1 | \$, MILLIONS | | | |
| CD=CDCER X (T X DF)XX(CDEXP) X CF | | | | 0.0 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 0.006 | | | |
| ORM =T / M | | | | 30.000 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 1.000 | | | |
| CIFU=(CLRM / E)X(ORM X Z1+0.5)XX(E) -0.5XX(E)) | | | | 1.053 | | | |
| CTB =((CLRM/E)X(ORM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | |) / Z3 | | | |
| CIPS=CTB*Z4/Z2 | | | | 0.047 | | | |
| CRCI =CTB X R | | | | 0.0 | | | |
| PRE-IOC CRCI =CRCI X Z6 | | | | 0.0 | | | |
| POST-IOC CRCI =CRCI X (1.0-Z6) | | | | 0.0 | | | |
| COEM =OEM OR CTR*Z5/Z2/ENYR | | | | 0.000 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND OEM WERE 0.0 0.000050 0.0 | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.3.2.1.5 CONCENTRATOR

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|------------|------|----------------|--------------------|----------|----------|----------|
| T= | 1823200.00 | TF= | 1.000000 | CDLER= | | 0.031590 | |
| M= | 474500.000 | UEM= | 0.0 | CDEXP= | | 0.394000 | |
| CF= | 1.000000 | Z1= | 6.000000 | CICER= | | 0.000004 | |
| PHI= | 0.980000 | Z2= | 60.000000 | CIEXP= | | 0.950000 | |
| R= | 0.001111 | Z3= | 22.000000 | BYEAR= | | 1979 | |
| DF= | 0.020000 | Z4= | 16.000000 | Z5= | 4.000000 | Z6= | 0.800000 |
| CALCULATED VALUES | | SQ M | SUM TO 1.3.2.1 | \$,MILLIONS | | | |
| CD=CDLER X (T X DF)XX(CDEXP) X CF | | | | 1.981 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 0.866 | | | |
| ERM =T / M | | | | 3.842 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 0.971 | | | |
| CTFU=(CLRM / E)X((ERM X Z1+.5)XX(E) -0.5XX(E)) | | | | 18.716 | | | |
| CTB =((CLRM/E)X((ERM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | |) / Z3 | | 3.010 | |
| LIPS=CTB*Z4/Z2 | | | | 0.803 | | | |
| CRC1 =CTB X R | | | | 0.003 | | | |
| PRE-IOC CRC1 =CRC1 X Z6 | | | | 0.003 | | | |
| POST-IOC CRC1 =CRC1 X (1.0-Z6) | | | | 0.001 | | | |
| CUEM =UEM OR CTR*Z5/Z2/ENYR | | | | 0.007 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDLER, CICER, AND UEM WERE | | | | 0.027000 | 0.000003 | 0.0 | |
| DENSITY= .0181 KG PER SQ METER. MASS 33000 KG | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.3.2.1.6 SOLAR BLANKET

INPUT PARAMETERS

INPUT COEFFICIENTS

| | | | | | |
|------|------------|------|-----------|--------|----------|
| T= | 949000.000 | TF= | 1.000000 | CDCER= | 0.188838 |
| M= | 18250.0000 | DEM= | 0.0 | CDEXP= | 0.394000 |
| CF= | 1.200000 | Z1= | 6.000000 | CICER= | 0.000078 |
| PHI= | 0.990000 | Z2= | 60.000000 | CIEXP= | 1.000000 |
| R= | 0.001111 | Z3= | 22.000000 | BYEAR= | 1979 |
| DF= | 0.500000 | Z4= | 16.000000 | Z5= | 4.000000 |
| | | | | Z6= | 0.800000 |

CALCULATED VALUES

SQ M

SUM TO 1.3.2.1

\$, MILLIONS

$$CD = CDCER \times (T \times DF) \times (CDEXP) \times CF$$

39.058

$$CLRM = CICER \times (M) \times (CIEXP) \times CT \times TF$$

1.717

$$E = T / M$$

52.000

$$E = 1.0 + \text{LOG}(PHI) / \text{LOG}(2.0)$$

0.986

$$CTFU = (CLRM / E) \times (1 + 0.5 \times (E) - 0.5 \times (E))$$

499.988

$$CTB = ((CLRM / E) \times (1 + 0.5 \times (E) - 0.5 \times (E))) / Z3$$

81.786

$$CIPS = CTB \times Z4 / Z2$$

21.810

$$CRCI = CTB \times R$$

0.091

$$\text{PRE-IOC } CRCI = CRCI \times Z6$$

0.073

$$\text{POST-IOC } CRCI = CRCI \times (1.0 - Z6)$$

0.018

$$COEM = DEM \text{ OR } CTR \times Z5 / Z2 / ENYR$$

0.182

COMMENTS

1977 DATA ENTERED FOR CDCER, CICER, AND DEM WERE 0.161400 0.000067 0.0
NASA/ADL NAS 9-15294 MARCH 1978
\$67/SQ M (1977 DOLLARS). HTLS \$33/SQ M & PROCESSING \$34/SQ M. DENSITY=
0.2525 KG PER SQ M. 2 SECTIONS, 26 PANELS EACH.

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.3.2.1.7 SWITCHGEAR AND REGULATORS

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|------------|------|----------------|--------------------|----------|-------|----------|
| T= | 4700.00000 | TF= | 1.000000 | CDCER= | 0.184860 | | |
| M= | 52.000000 | DEM= | 0.0 | CDEXP= | 0.297000 | | |
| CF= | 1.500000 | Z1= | 6.000000 | CICER= | 0.000468 | | |
| Phi= | 0.950000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.001111 | Z3= | 22.000000 | RYEAR= | 1979 | | |
| DF= | 0.500000 | Z4= | 16.000000 | Z5= | 4.000000 | Z6= | 0.800000 |
| CALCULATED VALUES | | KG | SUM TO 1.3.2.1 | \$,MILLIONS | | | |
| CD=CDCER X (1 X DF)XX(CDEXP) X CF | | | | 2.781 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 0.037 | | | |
| EORM =T / M | | | | 90.385 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 0.926 | | | |
| CTFU=(CLRM / E)X((EORM X Z1+0.5)XX(E) -0.5XX(E)) | | | | 13.407 | | | |
| CTB =((CLRM/E)X((EORM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | |) / Z3 | | 2.031 | |
| CIPS=CTB*Z4/Z2 | | | | 0.542 | | | |
| CRC1 =CTB X R | | | | 0.002 | | | |
| PRE-IDC CRC1 =CRC1 X Z6 | | | | 0.002 | | | |
| POST-IDC CRC1 =CRC1 X (1.0-Z6) | | | | 0.000 | | | |
| COEM =DEM OR CTB*Z5/Z2/ENR | | | | 0.005 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CULER, CICER, AND DEM WERE 0.158000 0.000400 0.0 | | | | | | | |
| 1 DAY (2 SECTIONS). Z6 SETS PER SECTION. INCLUDES 2000 KG FOR ACS | | | | | | | |
| POWER PROCESSING EQUIPMENT | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.3.2.1.8 LD-VOLTAGE CONVERTERS

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|------------|------|----------------|--------------------|----------|-------|----------|
| T= | 300.000000 | TF= | 1.000000 | CDCER= | 0.184860 | | |
| M= | 5.770000 | DEM= | 0.0 | COEXP= | 0.297000 | | |
| CF= | 1.200000 | Z1= | 6.000000 | CICER= | 0.000468 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.001111 | Z3= | 22.000000 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 16.000000 | Z5= | 4.000000 | Z6= | 0.800000 |
| CALCULATED VALUES | | KG | SUM TO 1.3.2.1 | \$,MILLIONS | | | |
| CU=CDCER X (T X DF)XX(COEXP) X CF | | | | 1.207 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 0.003 | | | |
| FORM = T / M | | | | 51.993 | | | |
| E = 1.0 + LOG(PHI) / LOG(2.0) | | | | 1.000 | | | |
| CTFU=(CLRM / E)X((FORM X Z1+0.5)XX(E) -0.5XX(E)) | | | | 1.011 | | | |
| CTB =((CLRM/E)X((FORM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | |) / Z3 | | 0.168 | |
| CIPS=CTB*Z4/Z2 | | | | 0.045 | | | |
| CRCI =CTB X R | | | | 0.000 | | | |
| PRE-IOC CRCI =CRCI X Z6 | | | | 0.000 | | | |
| POST-IOC CRCI =CRCI X (1.0-Z6) | | | | 0.000 | | | |
| COEM =DEM OR CTB*Z5/Z2/ENYR | | | | 0.000 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND DEM WERE 0.158000 0.000400 0.0 | | | | | | | |
| 1 BAY (2 SECTIONS) WITH 26 SETS OPERATING PER SECTION | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.3.2.1.9 CONDUCTORS AND INSULATION

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|---|------------|------|----------------|--------------------|--------------|-----|----------|
| T= | 265000.000 | TF= | 1.000000 | CDCER= | 0.184860 | | |
| M= | 5100.00000 | LEM= | 0.0 | CDEXP= | 0.297000 | | |
| CF= | 1.000000 | Z1= | 6.000000 | CICER= | 0.000005 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.0 | Z3= | 20.000000 | BYEAR= | 1979 | | |
| DF= | 0.100000 | Z4= | 16.000000 | Z5= | 4.000000 | Z6= | 0.800000 |
| CALCULATED VALUES | | KG | SUM TO 1.3.2.1 | | \$. MILLIONS | | |
| CD=CDCER X (T X DF)X(CDEXP) X CF | | | | | 3.807 | | |
| CLRM=CICER X (M)X(CIEXP) X CF X TF | | | | | 0.024 | | |
| FORM = T / M | | | | | 51.961 | | |
| E = 1.0 + LOG(PHI) / LOG(2.0) | | | | | 1.000 | | |
| CTFU=(CLRM / E)X((FORM X Z1+0.5)X(E) -0.5X(E)) | | | | | 7.441 | | |
| CTB =(CLRM/E)X((FORM X Z3 + 0.5)X(E) -0.5X(E)) | | | 1 / Z3 | | 1.240 | | |
| CIPS=CTB*Z4/Z2 | | | | | 0.331 | | |
| CRC1 =CTB X R | | | | | 0.0 | | |
| PRE-IDC CRC1 =CRC1 X Z6 | | | | | 0.0 | | |
| POST-IDC CRC1 =CRC1 X (1.0-Z6) | | | | | 0.0 | | |
| COEM =DEM OR CTB*Z5/Z2/ENVR | | | | | 0.003 | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CULR, CICER, AND DEM WERE 0.158000 0.000004 0.0 | | | | | | | |
| 5920 KG ALLOCATED TO ACS. 1 BAY (2 SECTIONS) 26 SETS PER SECTION | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.3.2.1.10 BATTERIES

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|------------|------|----------------|--------------------|----------|---------|----------|
| T= | 152000.000 | TF= | 1.000000 | CDCER= | 0.040145 | | |
| M= | 50.000000 | DEM= | 0.0 | CDEXP= | 0.734000 | | |
| CF= | 1.200000 | Z1= | 6.000000 | CICER= | 0.030380 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 0.241000 | | |
| R= | 0.011111 | Z3= | 40.000000 | BYEAR= | 1979 | | |
| DF= | 0.003000 | Z4= | 16.000000 | Z5= | 6.600000 | Z6= | 0.600000 |
| CALCULATED VALUES | | KG | SUM TO 1.3.2.1 | \$,MILLIONS | | | |
| CD=CDCER X (T X DF)XX(CDEXP) X CF | | | | 4.310 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 0.094 | | | |
| IORM =T / M | | | | 3040.000 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 1.000 | | | |
| CTFU=(CLRM / E)X(IORM X Z1+0.5)XX(E) -0.5XX(E) | | | | 1707.046 | | | |
| CTB =((CLRM/E)X(IORM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | | 1 / Z3 | | 284.508 | |
| CIPS=CTB*24/Z2 | | | | 75.869 | | | |
| CRCI =CTB X R | | | | 3.161 | | | |
| PRE-IOC CRCI =CRCI X Z6 | | | | 2.529 | | | |
| POST-IOC CRCI =CRCI X (1.0-Z6) | | | | 0.632 | | | |
| COEM =DEM OR CTB*25/22/ENYR | | | | 1.043 | | | |
| COMMENTS | | | | | | | |
| 1978 DATA ENTERED FOR CDCER, CICER, AND DEM WERE 0.037000 0.028000 0.0 | | | | | | | |
| INCLUDES BATTERIES FOR ACS. CF CONSIDERS SODIUM CHLORIDE VERSUS DATA BASE. | | | | | | | |
| 15 YEAR LIFE. COEM COVERS 4 VEHICLE BATTERY SETS ASSOC. WITH DEM ACTIVITIES PLUS | | | | | | | |
| 2.2 EQUIVALENTS FOR \$412300 ANNUAL MAINT. SEE 1.1.1.4.5 FOR DOTCE | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.3.2.1.11 BATTERY PDEC

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|------------|------|----------------|--------------------|--------------|-----|----------|
| T= | 2000.00000 | TF= | 1.000000 | CDCER= | 0.057505 | | |
| M= | 250.000000 | UGM= | 0.0 | CDEXP= | 0.890000 | | |
| CF= | 1.000000 | Z1= | 6.000000 | CICER= | 0.013020 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 0.859000 | | |
| R= | 0.001666 | Z3= | 23.000000 | BYEAR= | 1979 | | |
| DF= | 0.100000 | Z4= | 16.000000 | Z5= | 4.000000 | Z6= | 0.800000 |
| CALCULATED VALUES | | K6 | SUM TO 1.3.2.1 | | \$, MILLIONS | | |
| CD=CDCER X (T X DF)XX(CDEXP) X CF | | | | | 6.421 | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | | 1.494 | | |
| ERM = T / M | | | | | 8.000 | | |
| E = 1.0 + LOG(PHI) / LOG(2.0) | | | | | 1.000 | | |
| CTFU=(CLRM / E)X(ERM X Z1+0.5)XX(E) -0.5XX(E) | | | | | 71.727 | | |
| CTB =((CLRM/E)X(ERM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | | / Z3 | 11.954 | | |
| CIPS=CTB*Z4/Z2 | | | | | 3.188 | | |
| CRCI =CTB X R | | | | | 0.020 | | |
| PRE-IDC CRCI =CRCI X Z6 | | | | | 0.016 | | |
| PUST-IDC LRCI =CRCI X (1.0-Z6) | | | | | 0.004 | | |
| COEM =UGM OR LTP*Z5/Z2/ENVR | | | | | 0.027 | | |
| COMMENTS | | | | | | | |
| 1978 DATA ENTERED FOR CDCER, CICER, AND UGM WERE | | | | 0.053000 | 0.012000 | 0.0 | |
| INCLUDES PDEC FOR ACS BATTERIES | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.3.2.1.12 ACS HARDWARE-COTV

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | |
|---|------------|------|----------------|--------------------|----------|--------------|
| T= | 109000.000 | TF= | 0.300000 | CDCER= | 1.312739 | |
| M= | 908.000000 | OEM= | 0.0 | CDEXP= | 0.190000 | |
| CF= | 1.000000 | Z1= | 6.000000 | CICER= | 0.066690 | |
| PHI= | 0.980000 | Z2= | 60.000000 | CIEXP= | 0.729000 | |
| R= | 0.001111 | Z3= | 22.000000 | BYEAR= | 1979 | |
| DF= | 0.300000 | Z4= | 16.000000 | Z5= | 4.000000 | Z6= 0.800000 |
| CALCULATED VALUES | | KG | SUM TO 1.3.2.1 | \$,MILLIONS | | |
| CD=CDCER X (T X DF)XX(CDEXP) X CF | | | | 9.461 | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 2.868 | | |
| E = T / M | | | | 120.044 | | |
| E = 1.0 + LOG(PHI) / LOG(2.0) | | | | 0.971 | | |
| CIFU=(CLRM / E)X(1+Z1X(1-E) -0.5XX(E)) | | | | 1756.297 | | |
| CTB =(1+(CLRM/E)X(1+Z3X(1-E) -0.5XX(E)) | | | | 1 / Z3 | | |
| CIPS=CTB*Z4/Z2 | | | | 75.166 | | |
| CRCI =CTB X R | | | | 0.313 | | |
| PRE-10C CRCI =CRCI X Z6 | | | | 0.251 | | |
| POST-10C (RCI =CRCI X (1.0-Z6) | | | | 0.063 | | |
| COEM =OEM OR CTR*Z5/Z2/ENR | | | | 0.626 | | |
| COMMENTS | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND OEM WERE 1.122000 0.057000 0.0 | | | | | | |
| INCLUDES 120 THRUSTERS 1M BY 1.5M; TANKS PROPELLANT LINES, AND ATTITUDE | | | | | | |
| REFERENCE SYSTEM | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.3.2.1.13 INFU. MGMT. AND CONTROL

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|------------|----------------|-----------|--------------------|----------|--------|----------|
| T= | 2000.00000 | TF= | 1.000000 | CDCER= | 0.740610 | | |
| M= | 500.000000 | LEM= | 0.0 | CDEXP= | 0.521000 | | |
| CF= | 1.000000 | Z1= | 6.000000 | CICER= | 0.201240 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 0.535000 | | |
| R= | 0.001111 | Z3= | 22.000000 | BYEAR= | 1979 | | |
| DF= | 0.500000 | Z4= | 16.000000 | Z5= | 4.000000 | Z6= | 0.800000 |
| CALCULATED VALUES | | SUM TO 1.3.2.1 | | \$,MILLIONS | | | |
| CD=CDCER X (T X DF)XX(CDEXP) X CF | | | | 27.076 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 5.993 | | | |
| E = T / M | | | | 4.000 | | | |
| E = 1.0 + LOG(PHI) / LOG(2.0) | | | | 1.000 | | | |
| CTFU=(CLRM / E)X((ORM X Z1+.5)XX(E) -0.5XX(E)) | | | | 134.238 | | | |
| CTB =((CLRM/E)X((ORM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | |) / Z3 | | 22.373 | |
| CIPS=CTB*Z4/Z2 | | | | 5.966 | | | |
| CRCI =CTB X R | | | | 0.025 | | | |
| PRE-IDC CRCI =CRCI X Z6 | | | | 0.020 | | | |
| POST-IDC CRCI =CRCI X (1.0-Z6) | | | | 0.005 | | | |
| OEM =OEM OR CTN*Z5/Z2/ENYR | | | | 0.050 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND OEM WERE | | | | 0.633000 | 0.172000 | 0.0 | |
| COVERS ALL IMS ON EDTV | | | | | | | |

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1.3.2.2 COTV OPERATIONS

Necessary vehicle operations (user charge per flight including payload integration) are included in this element.

The flight life of the EOTV is estimated at 20 roundtrips from LEO to GEO. Three-hundred twenty flights are required for the construction of 60 satellites and an additional 72 flights will maintain operations of a satellite for the 30-year period. Eight flights are required to build the first satellite.

Calculations used in this cost estimate are presented in Table 1.3.2.2.

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.3.2.2 CUTV OPERATIONS

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|----------|--------|------------|--------------------|-----------|--------------|----------|
| T= | 1.000000 | TF= | 1.000000 | CDCER= | 0.0 | | |
| M= | 1.000000 | UEM= | 0.0 | CDEXP= | 0.0 | | |
| CF= | 1.000000 | Z1= | 0.000000 | CICER= | 0.942575 | | |
| PHI= | 1.000000 | Z2= | 00.000000 | CIEXP= | 1.000000 | | |
| R= | 0.0 | Z3= | 392.000000 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 320.000000 | Z5= | 72.000000 | Z6= | 0.816330 |
| CALCULATED VALUES | | FLIGHT | | SUM TO 1.3.2 | | \$, MILLIONS | |
| CU=CDCER X (T X DF)XX(CDEXP) X CF | | | | | | 0.0 | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | | | 0.943 | |
| ORM =T / M | | | | | | 1.000 | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | | | 1.000 | |
| CTFU=(CLRM / E)X(ORM X Z1+0.5)XX(E) -0.5XX(E)) | | | | | | 7.541 | |
| CTB =((CLRM/E)X(ORM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | |) / Z3 | | 0.943 | |
| CIPS=CTB*Z4/Z2 | | | | | | 5.027 | |
| CRC1 =CTB X R | | | | | | 0.0 | |
| PRE-IOC CRC1 =CRC1 X Z6 | | | | | | 0.0 | |
| POST-IOC CRC1 =CRC1 X (1.0-Z6) | | | | | | 0.0 | |
| COEM =UEM OR CTB*Z5/Z2/ENYR | | | | | | 0.038 | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND UEM WERE | | | | 0.0 | 0.805620 | 0.0 | |
| R.T. PROPELLANT PER FLIGHT=870000 KG | | | | | | | |

1.3.3 STS PERSONNEL/CARGO LAUNCH VEHICLE

This element covers STS requirements in support of personnel and cargo transfer to LEO for the fabrication and assembly of the SPS LEO base and space construction fixture (SCB). STS "growth" vehicles will be used as a personnel/cargo launch vehicle after the replacement of solid rocket boosters with liquid rocket boosters and the use of a personnel module within the orbiter as needed. The STS-derivative HLLV (100,000 kg payload to LEO) will require STS modification by adding liquid rocket boosters and the replacement of the orbiter with a cargo carrier and EM. The SPS VTO/HL HLLV (WBS 1.3.1) will be used for subsequent space operations to fabricate EOTV and SPS satellite requirements.

Flight requirements to build the SCB and LEO base are summarized in Table 1.3-8 for the five concepts costed. The size of the SCB needed to fabricate solid-state sandwich concepts will require more flights to transfer the necessary mass.

The frequency of STS growth vehicle flights can be satisfied by the use of one launch vehicle, whereas it is contemplated that two vehicles are needed in the fleet to support derivative (cargo only) requirements. It is also assumed that DDT&E costs for the growth and derivative vehicles will be absorbed by contract activity associated with other supporting programs.

Two personnel modules (PM) are adequate to satisfy mission requirements for the STS growth vehicle. These PMs are included in the costing under WBS 1.3.5.

Costing of the STS cargo carrier and engine module is presented in the next section (1.3.3.1). STS operations costing of growth and derivative vehicles is described in Section 1.3.3.2.

Table 1.3-8. STS Personnel and Cargo Launch Vehicle Flight Requirements
(SCB and LEO Base)

| SPS CONCEPT | STS GROWTH VEHICLE (PERSONNEL/CARGO) | STS DERIVATIVE VEHICLE (CARGO) | STS CARGO CARRIERS & ENGINE MODULES |
|---|--|--------------------------------------|---|
| • ROCKWELL REFERENCE CR-2 CONFIG. (3-TROUGH/PLANAR/KLYSTRON)— GaAs | 72 FLIGHTS | 63 FLIGHTS | 2 |
| • ROCKWELL MAGNETRON CR-2 CONFIG. (3-TROUGH/PLANAR/MAGNETRON)— GaAs | 72 FLIGHTS | 63 FLIGHTS | 2 |
| • DUAL END-MOUNTED ANTENNA, CR-2 (3-TROUGH/PLANAR/SOLID-STATE)— GaAs | 72 FLIGHTS | 63 FLIGHTS | 2 |
| • SOLID-STATE SANDWICH CR-5 CONFIG. (DUAL ANTENNA AND REFLECTORS)— GaAs | 72 FLIGHTS | 168 FLIGHTS | 2 |
| • SOLID-STATE SANDWICH CR-5 CONFIG. (DUAL ANTENNA AND REFLECTORS)— HfG | 72 FLIGHTS | 168 FLIGHTS | 2 |
| COST ESTIMATE PER FLIGHT | $\$20.25 \times 10^6$ | $\$15.19 \times 10^6$ | |

1.3.3.1 STS CARGO CARRIER AND EM

This element includes a container for cargo and an integral engine module to transport mass to orbit in conjunction with the STS booster as a lift vehicle. The STS HLLV consists of a standard external tank with two liquid rocket boosters. The cargo/engine module replaces the orbiter.

Cost estimates were developed from work under Rockwell's Shuttle Growth Study Contract (NAS8-32015) dated May 1977. DDT&E and hardware costs of the carrier and engine module were identified by comparative evaluation with a Shuttle growth data base. Two cargo/EM carriers are needed for use in building the SCB and LEO base facility. Table 1.3.3.1 presents cost data on this WBS element.

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.3.3.1 SIS CARGO CARRIER AND EM

INPUT PARAMETERS

INPUT COEFFICIENTS

| | | | | | |
|-----|----------|-----|-----------|-------|------------|
| Tn | 1.000000 | TF | 1.000000 | CDCER | 286.649902 |
| M | 1.000000 | UGM | 0.0 | CDEXP | 1.000000 |
| CF | 1.000000 | Z1 | 2.000000 | CICER | 310.985840 |
| PHI | 0.950000 | Z2 | 60.000000 | CIEXP | 1.000000 |
| R | 0.0 | Z3 | 2.000000 | BYEAR | 1979 |
| DF | 1.000000 | Z4 | 2.000000 | Z5 | 0.0 |
| | | | | Z6 | 0.0 |

CALCULATED VALUES

S

SUM TO 1.3.3

\$, MILLIONS

CD=CDCER X (1 X DF)XX(CDEXP) X CF 286.650

CLRM=CICER X (M)XX(CIEXP) X CF X TF 310.986

ORM = 1 / M 1.000

E = 1.0 + LOG(PHI) / LOG(2.0) 0.926

CTFU=(CLRM / E)X(ORM X Z1+0.5)XX(E) -0.5XX(E) 607.795

CTB =(1CLRM/E)X(ORM X Z3 + 0.5)XX(E) -0.5XX(E) 1 / Z3 303.897

CIPS=CTB*Z4/Z2 10.130

CRC1 =CTB X R 0.0

PRE-IDC CRC1 =CRC1 X Z6 0.0

POST-IDC CRC1 =CRC1 X (1.0-Z6) 0.0

COEM =OEM OR CIP*Z5/Z2/E*NR 0.0

COMMENTS

1977 DATA ENTERED FOR CDCER, CICER, AND UGM WERE 245.000000 265.800049 0.0
2 CARGO/EM CARRIERS FOR USE IN BUILDING SPACE CONSTRUCTION BASE AND LEO
FACILITY. NO RC1 OR UGM. DUTY INCLUDED

1.3.3.2 STS OPERATIONS—GROWTH AND DERIVATIVE HLLV

This element covers the cost of necessary vehicle operations required to support the fabrication of the LEO base and the space construction facility.

A total of 135 flights is required of STS growth and derivative HLLVs to transport the required mass to orbit. Seventy-two flights are needed for personnel primarily (STS growth vehicle) and 63 flights of the STS derivative vehicle are required for cargo transfer to LEO.

The cost of operations is based on a per flight estimate established after careful analysis of STS user charges extrapolated to values for use in early SPS operational support and as scaled to expected operational efficiencies and experiences. The per flight cost of STS growth vehicle (personnel) support was established at 75% of STS Shuttle flight costs ($\$27 \times 10^6$) considering liquid rocket booster advantages, advanced design improvements, and operational experience. Costs per STS derivative (cargo only) flights were estimated at 75% of "growth" charges because the mission is unmanned and the orbiter is not required.

Tables 1.3.3.2.1 and 1.3.3.2.2 cover operational cost estimates.

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.3.3.2.1 OPERATIONS-STS GROWTH MLLV

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|---|----------|---------|-----------|--------------------|-----------|-------------|-----|
| T= | 1.000000 | TF= | 1.000000 | CDCER= | 0.0 | | |
| M= | 1.000000 | UEM= | 0.0 | CDEXP= | 0.0 | | |
| CF= | 1.000000 | Z1= | 72.000000 | CICER= | 20.250000 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.0 | Z3= | 72.000000 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 72.000000 | Z5= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | FLIGHTS | | SUM TO 1.3.3.2 | | \$,MILLIONS | |
| CD=CDCER X (T X DF)XX(CDEXP) X CF | | | | | | 0.0 | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | | | 20.250 | |
| WRM = T / M | | | | | | 1.000 | |
| E = 1.0 + LOG(PHI) / LOG(2.0) | | | | | | 1.000 | |
| CTFU=(CLRM / E)X((WRM X Z1+0.5)XX(E) -0.5XX(E)) | | | | | | 1458.000 | |
| CTB = ((CLRM/E)X((WRM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | | 1 / Z3 | | 20.250 | |
| CIPS=CTB*Z4/Z2 | | | | | | 24.300 | |
| CRC1 =CTB X R | | | | | | 0.0 | |
| PRE-100 LRC1 =CRC1 X Z6 | | | | | | 0.0 | |
| POST-100 CRC1 =CRC1 X (1.0-Z6) | | | | | | 0.0 | |
| COEM =UEM OR CTH*Z5/Z2/EAYR | | | | | | 0.0 | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND UEM WERE 0.0 17.307693 0.0 | | | | | | | |
| USER FEE ESTABLISHED ON A PER FLIGHT BASIS. FLIGHTS SUPPORT SCR AND LEO | | | | | | | |
| BASE FABRICATION. | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.3.3.2.2 OPERATIONS - STS DERIVATIVE

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|---|----------|------|-----------|----------------------------|-----------|-----|-----|
| T= | 1.000000 | TF= | 1.000000 | CDCER= | 0.0 | | |
| M= | 1.000000 | DEM= | 0.0 | CDEXP= | 0.0 | | |
| CF= | 1.000000 | Z1= | 63.000000 | CICER= | 15.190000 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.0 | Z3= | 63.000000 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 63.000000 | Z5= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | | | SUM TO 1.3.3.2 \$,MILLIONS | | | |
| CD=CDCER X (T X DF)XX(CDEXP) X CF | | | | 0.0 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 15.190 | | | |
| ΘRM =T / M | | | | 1.000 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 1.000 | | | |
| CTFU=(CLRM / E)X((ΘRM X Z1+0.5)XX(E) -0.5XX(E)) | | | | 956.970 | | | |
| CTB =((CLRM/E)X((ΘRM X Z3 + 0.5)XX(E) -0.5XX(E))) | | | | 1 / Z3 15.190 | | | |
| CIPS=CTB*Z4/Z2 | | | | 15.949 | | | |
| CRC1 =CTB X R | | | | 0.0 | | | |
| PRE-IOC CRC1 =CRC1 X Z6 | | | | 0.0 | | | |
| POST-IOC CRC1 =CRC1 X (1.0-Z6) | | | | 0.0 | | | |
| COEM =DEM OR CTB*Z5/Z2/EMR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND DEM WERE 0.0 12.982905 0.0 | | | | | | | |
| USER FEE ESTABLISHED UN \$ PER FLIGHT BASIS. FLIGHTSSUPPORT SCB AND | | | | | | | |
| LEO BASE FABRICATION. | | | | | | | |

1.3.4 PERSONNEL ORBITAL TRANSFER VEHICLE (POTV)

This element includes POTV vehicles and operations required in support of satellite system assembly and operation. Included is the LEO-to-GEO and return of all personnel and priority cargo required throughout satellite construction and operational periods.

All POTV options evaluated utilize a single-state propulsive element that is fueled in LEO and refueled in GEO for the return flight. The mated configuration (POTV/PM) is illustrated in Figure 1.3-12 where the POTV (a propulsive chemical stage) is capable of transporting a 60-person module (PM) of 18,000 kg.

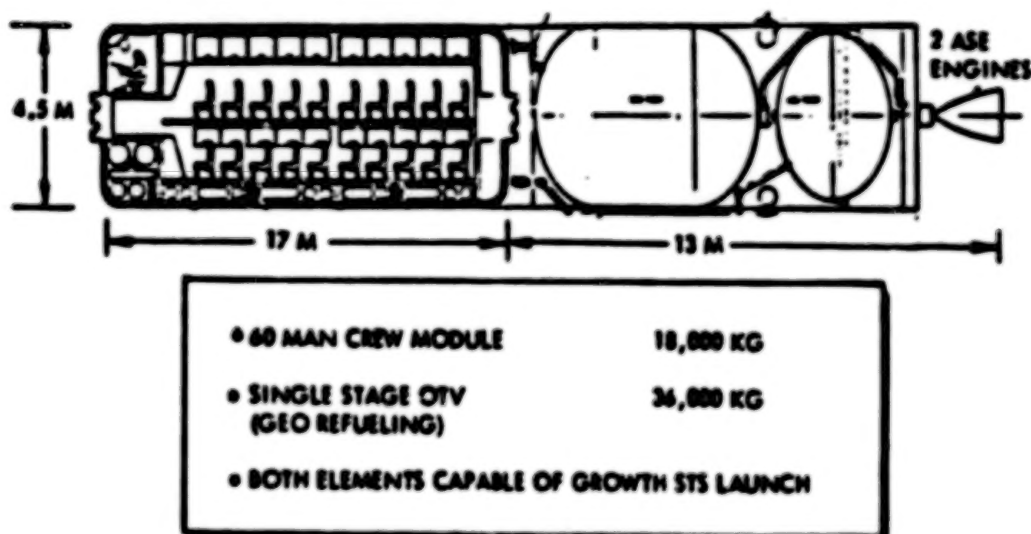


Figure 1.3-12. POTV Configuration

The vehicle is costed in Section 1.3.4.1, and POTV operations are covered in Section 1.3.4.2.

1.3.4.1 POTV FLEET

The POTV fleet required to support the SPS program is included in this element. The POTV is a single-stage OTV of 36,000 kg for the transfer of a 60-person crew module to LEO with refueling at GEO for the return to LEO. Propellants are carried from LEO to GEO by the EOTV at considerable overall savings. The SPS HLLV carried construction materials, crew, expendables, and propellants to LEO.

The single-stage OTV configuration selected is a scaled version of those concepts presented in the BAC FSTSA NAS9-24323 contract and engineering analyses presented in Exhibits A/B of the Rockwell contract, NAS8-32475. DDT&E estimates considered fewer engines, a significant difference in mass, and the degree of development required for the engines. Engineering analyses of available vehicle estimates projected a POTV cost based on the design and complexity of the vehicle.

POTV cost estimates are presented in Table 1.3.4.1 for a total fleet of 45 vehicles with (1) 12 for personnel involved in satellite construction, (2) 3 for SPS operational activities, and (3) an attrition factor of 30 equivalent vehicles to keep the fleet fully operational.

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.3.4.1 PUTV-FLEET

INPUT PARAMETERS

INPUT COEFFICIENTS

| | | | | | | | | |
|------|----------|------|-----------|--------|------------|-----|----------|----------|
| T= | 1.000000 | TF= | 1.000000 | CDCER= | 409.500000 | | | |
| M= | 1.000000 | UEM= | 0.0 | CDEXP= | 1.000000 | | | |
| CF= | 1.000000 | Z1= | 4.000000 | CICER= | 17.549988 | | | |
| PHI= | 0.950000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | | |
| R= | 0.016666 | Z3= | 45.000000 | BYEAR= | 1979 | | | |
| DF= | 1.000000 | Z4= | 12.000000 | | | 25= | 3.000000 | |
| | | | | | | | 26= | 0.800000 |

CALCULATED VALUES

SET

SUM TU 1.3.4

\$, MILLIONS

CD=CDCER X (T X DF)XX(CDEXP) X CF 409.500

CLRM=CICER X (M)XX(CIEXP) X CF X TF 17.550

ORM = T / M 1.000

E = 1.0 + LOG(PHI) / LOG(2.0) 0.926

CTFU=(CLRM / E)X((ORM X Z1+0.5)XX(E) -0.5XX(E)) 66.328

CTB = ((CLRM/E)X((ORM X Z3 + 0.5)XX(E) -0.5XX(E))) / Z3 14.225

CIPS=CTB*Z4/Z2 2.845

CRC1 =CTB X R 0.237

PRE-IOC CRC1 =CRC1 X Z6 0.190

POST-IOC CRC1 =CRC1 X (1.0-Z6) 0.047

COEM =UEM OR CTB*Z5/Z2/ENR 0.024

COMMENTS

1977 DATA ENTERED FOR CDCER, CICER, AND UEM WERE 350.000000 15.000000 0.0
45 PUTV VEHICLES WITH 12 CONSTRUCTION RELATED AND 3 UEM RELATED. 30 FOR
RC1

1.3.4.2 POTV OPERATIONS

This element includes necessary vehicle operations (user charge per flight including payload integration) required to support SPS program and required personnel.

The primary operational cost of the POTV is the cost of fuel. A total of 1544 flights was costed on this basis with 1220 flights for satellite construction support, and 324 for operations and maintenance.

Table 1.3.4.2 presents the results of this analysis.

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.3.4.2 PUTV-OPERATIONS

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|----------|---------|------------|--------------------|------------|----------|-------|
| T= | 1.000000 | TF= | 1.000000 | CDCER= | 0.0 | | |
| M= | 1.000000 | UEM= | 0.0 | CDEXP= | 0.0 | | |
| CF= | 1.000000 | Z1= | 40.000000 | CICER= | 0.040230 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.0 | Z3= | 1544.00000 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 1220.00000 | Z5= | 324.000000 | Z6= | 0.0 |
| CALCULATED VALUES | | FLIGHTS | | SUM TO 1.3.4 | | MILLIONS | |
| CD=CDCER X (T X DF)XX(CDEXP) X CF | | | | | | 0.0 | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | | | 0.040 | |
| ORM =T / M | | | | | | 1.000 | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | | | 1.000 | |
| CTFU=(CLRM / E)X(ORM X Z1+0.5)XX(Z2) -0.5XX(E) | | | | | | 1.609 | |
| CTB =((CLRM/E)X(ORM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | | | | 1 / Z3 | 0.040 |
| CIPS=CTB*Z4/Z2 | | | | | | 0.818 | |
| CRC1 =CTB X R | | | | | | 0.0 | |
| PRE-IOC CRC1 =CRC1 X Z6 | | | | | | 0.0 | |
| POST-IOC CRC1 =CRC1 X (1.0-Z6) | | | | | | 0.0 | |
| COEM =DEM OR CT*Z5/Z2/ENVR | | | | | | 0.007 | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND UEM WERE | | | | 0.0 | 0.034385 | 0.0 | |

1.3.5 PERSONNEL MODULE (PM)

This element includes PM units and operations required to support satellite system assembly and operation. Included in the earth-to-LEO-to-GEO and return is the transfer of all personnel and critical hardware items required throughout satellite construction and operational periods. The PM provides a crew habitat during the orbit-to-orbit transfer of personnel as well as during the trip from earth. An illustration of the PM was shown in Figure 1.3-12. It has a 60-man capacity and is approximately 17 m long by 4.5 m in diameter. The SPS HLLV is used for the earth-to-LEO and return transfer of personnel and the POTV propulsion unit handles roundtrip movement from LEO-GEO-LEO.

1.3.5.1 PM FLEET

Procurement of the PM as required to support the SPS program is covered in this element. The PM is operated by a pilot and co-pilot and contains the major systems of life support, communication, seating, and support facilities. A total of 5 PMs are needed to support the program, and three equivalent PMs are considered sufficient to provide spares and major overhaul components for each PM during the program. Two vehicles will be required for early program supporting elements such as the LEO base and SCB.

Engineering cost projections were based on Rockwell company-funded studies of 1976 where DDT&E, a pair of 68 passenger modules, and orbiter modification kits were costed from internal design specifications. PM fleet procurement costs are presented in Table 1.3.5.1.

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ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.3.5.1 PM FLEET

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | |
|--|----------|------|--------------|--------------------|------------|--------------|
| T= | 1.000000 | TF= | 1.000000 | CDCER= | 138.059998 | |
| M= | 1.000000 | QCM= | 0.0 | CDEXP= | 1.000000 | |
| CF= | 1.000000 | Z1= | 5.000000 | CICER= | 63.647995 | |
| PHI= | 0.920000 | Z2= | 60.000000 | CIEXP= | 1.000000 | |
| R= | 0.008332 | Z3= | 20.000000 | BYEAR= | 1979 | |
| DF= | 1.000000 | Z4= | 4.000000 | Z5= | 1.000000 | Z6= 0.800000 |
| CALCULATED VALUES | | SET | SUM TO 1.3.5 | \$, MILLIONS | | |
| LD=CDCER X (T X DF)XX(CDEXP) X CF | | | | 138.060 | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 63.648 | | |
| SRM =T / M | | | | 1.000 | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 0.880 | | |
| CTFU=(CLRM / E)X(10RM X Z1+.5)XX(E) -0.5XX(E) | | | | 284.830 | | |
| CTB =((CLRM/E)X(10RM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | 1 / Z3 | 49.601 | | |
| CIPS=CTB*Z4/Z2 | | | | 3.307 | | |
| CRC1 =CTB X R | | | | 0.413 | | |
| PRE-IOC CRC1 =CRC1 X Z6 | | | | 0.331 | | |
| POST-IOC CRC1 =CRC1 X (1.0-Z6) | | | | 0.063 | | |
| COCM =QCM OR CTR*Z5/Z2/E*NR | | | | 0.020 | | |

COMMENTS

1977 DATA ENTERED FOR CDCER, CICER, AND QCM WERE 118.000000 54.399994 0.0
INCLUDES TWO PM'S FOR SIS (GROWTH) REQUIREMENTS TO BUILD THE SCB & LEO
BASE. THESE PM'S TO BE USED WITH 3 OTHERS FOR SRB, LEO BASE SPS CONSTR.
AND QCM.

1.3.5.2 PM OPERATIONS

This element includes necessary operations on a user charge per flight basis required to support the SPS program.

A pilot and co-pilot command the personnel module with a crew of 60 persons from earth to GEO and return. The initial journey is from earth to LEO, a transfer of the PM to a propulsion (POTV) unit for a roundtrip mission to GEO, and the safe return of personnel to earth. The crew will monitor passenger off-loading/transfer to and from the LEO base, SCB, or satellite mobile maintenance base. Two man-days are required per trip which includes a rest period at GEO and a day off after the trip. An average of 1738 roundtrips are projected from earth to GEO and back. A total of 1346 is planned for construction, and 392 are for operations and maintenance.

Engineering estimates of PM operations are presented in Table 1.3.5.2.

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.3.5.2 PM OPERATIONS

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|----------|--------|--------------|--------------------|------------|-----|-----|
| T= | 1.000000 | TF= | 1.000000 | CDCER= | 0.0 | | |
| M= | 1.000000 | QEM= | 0.0 | COEXP= | 0.0 | | |
| CF= | 1.000000 | Z1= | 102.000000 | CICER= | 0.029250 | | |
| Phi= | 1.000000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.0 | Z3= | 1738.00000 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 1346.00000 | Z5= | 392.000000 | Z6= | 0.0 |
| CALCULATED VALUES | | FLIGHT | SUM TO 1.3.5 | \$, MILLIONS | | | |
| CD=CDCER X (T X DF)XX(COEXP) X CF | | | | 0.0 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 0.029 | | | |
| E = T / M | | | | 1.000 | | | |
| E = 1.0 + LOG(PHI) / LOG(2.0) | | | | 1.000 | | | |
| CTFU=(CLRM / E)X((ORM X Z1+0.5)XX(E) -0.5XX(E)) | | | | 2.983 | | | |
| CTB = ((CLRM/E)X((ORM X Z3 + 0.5)XX(E) -0.5XX(E))) / Z3 | | | | 0.029 | | | |
| CIPS=CTB*Z4/Z2 | | | | 0.656 | | | |
| CRCI =CTB X R | | | | 0.0 | | | |
| PRE-IOC CRCI =CRCI X Z6 | | | | 0.0 | | | |
| POST-IOC CRLI =CRLI X (1.0-Z6) | | | | 0.0 | | | |
| COEM =QEM OR CTB*Z5/Z2/ENYR | | | | 0.006 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND QEM WERE 0.0 0.025000 0.0 | | | | | | | |
| 1738 FLIGHTS OF PM. 1346 ASSOCIATED WITH CONSTRUCTION OF SATELLITES. | | | | | | | |
| 72 ASSOCIATED WITH CONSTRUCTION OF SCB AND LEO BASE. 392 FLIGHTS FOR | | | | | | | |
| OEM SUPPORT. | | | | | | | |

1.3.6 INTRA-ORBITAL TRANSFER VEHICLE (IOTV)

This element includes IOTV vehicles and operations required to support satellite system assembly and operation. Included is the intra-orbit transfer of cargo between the HLLV, EOTV, construction facility, logistics support facility, and operational satellites.

1.3.6.1 IOTV FLEET

This element includes necessary vehicle fleet procurement required to support the SPS program. The IOTV has been synthesized in terms of application and concept only. IOTV elements considered here are powered by a chemical (LOX/LH₂) propulsion system. At least three distinct applications have been identified: (1) the need to transfer cargo from the HLLV to the EOTV in LEO and from the EOTV to the SPS construction base in GEO, (2) the need to move materials about the SPS construction base, and (3) the probable need to move men or materials between operational SPSs. Clearly, the POTV used for transfer of personnel from LEO to GEO and return is too large to satisfy all intra-orbit requirements. A "free-flyer" teleoperator concept would appear to be a logical solution to the problem. A propulsive element was synthesized to satisfy the cargo transfer application from HLLV-EOTV-SPS base in order to quantify potential on-orbit propellant requirements. Pertinent IOTV parameters are summarized in Table 1.3-9.

Table 1.3-9. IOTV Design Parameters

| SUBSYSTEM | WEIGHT (kg) |
|---------------------|-------------|
| ENGINE (1 ASE) | 245 |
| PROPELLANT TANKS | 15 |
| STRUCTURE AND LINES | 15 |
| DOCKING RING | 100 |
| ATTITUDE CONTROL | 50 |
| OTHER | 100 |
| SUBTOTAL | 525 |
| GROWTH (10%) | 53 |
| TOTAL INERT | 578 |
| PROPELLANT | 300 |
| TOTAL LOADED | 878 |

A total of 417 IOTVs is needed to maintain intra-orbit cargo/operations flow during the program; 112 vehicles will be dedicated to the construction phase, and 27 vehicles are needed for satellite C&M. An attrition/spares fleet of equivalent vehicles was projected on the ratio of two units for each of the operational vehicles.

Cost estimates for the IOTV are engineering assessments based on POTV designs and similarities such as those of the common advanced space engine (ASE). Table 1.3.6.1 displays applicable cost data.

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.3.6.1 IUTV FLEET

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|---|----------|------|--------------|--------------------|------------|-------|----------|
| T= | 1.000000 | TF= | 1.000000 | CDCR= | 117.000000 | | |
| M= | 1.000000 | UEM= | 0.0 | CDEXP= | 1.000000 | | |
| CF= | 1.000000 | Z1= | 4.000000 | CICER= | 1.755000 | | |
| PHI= | 0.950000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.154445 | Z3= | 417.000000 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 112.000000 | Z5= | 27.000000 | Z6= | 0.805755 |
| CALCULATED VALUES | | SET | SUM TO 1.3.6 | \$, MILLIONS | | | |
| CD=CDCR X (T X DF)X(CDEXP) X CF | | | | 117.000 | | | |
| CLRM=CICER X (M)X(CIEXP) X CF X TF | | | | 1.755 | | | |
| ORM =T / M | | | | 1.000 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 0.926 | | | |
| CTFU=(CLRM / E)X((ORM X Z1+0.5)X(E) -0.5X(E)) | | | | 6.633 | | | |
| CTB =((CLRM/E)X((ORM X Z3 + 0.5)X(E) -0.5X(E)) | | | |) / Z3 | | 1.212 | |
| CIPS=CTB*Z4/Z2 | | | | 2.262 | | | |
| CRC1 =CTB X R | | | | 0.187 | | | |
| PRE-IOC CRC1 =CRC1 X Z6 | | | | 0.151 | | | |
| POST-IOC CRC1 =CRC1 X (1.0-Z6) | | | | 0.036 | | | |
| COE= UEM OR CTE*Z5/Z2/ENVR | | | | 0.018 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CULER, LICH, AND OEM WERE 100.000000 1.500000 0.0 | | | | | | | |
| IUTV LIFE TIME = 200 FLIGHTS. RC1 REQUIRES 2 IOTV'S FOR EACH FLIGHT | | | | | | | |
| ITEM INCLUDING A MINIMAL ALLIANCE FOR OEM. | | | | | | | |

1.3.6.2 IOTV OPERATIONS

This element includes necessary IOTV operations and propellant costs required to support the SPS program. It includes the on-orbit operational cost of transferring cargo at LEO and GEO.

A total of 27,662 IOTV flights is planned for LEO and GEO construction and operations/maintenance requirements of the program; 22,323 flights are needed for construction, and 5339 flights for operations and maintenance. Equal-length missions are considered for the purposes of costing. Propellant requirements were averaged and calculated at 1979 dollars (Table 1.3-10). A 40% mark-up was added per flight for other operational and maintenance charges.

Table 1.3-10. Average Cost per IOTV Flight
(1979 Dollars)

| <u>Item</u> | <u>Amount ×10⁶ kg</u> | <u>\$/kg</u> | <u>\$/Flight</u> |
|-----------------|--------------------------------------|-----------------|------------------|
| LO ₂ | 0.000257 | 0.0819 | 21.00 |
| LH ₂ | 0.000043 | 3.826 | 165.00 |
| | | 40% contingency | 74.00 |
| | | | 260.00 |

IOTV operational costs are presented in Table 1.3.6.2.

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.3.6.2 JUTV OPERATIONS

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|----------|--------|------------|--------------------|------------|---------------|-----|
| T= | 1.000000 | TF= | 1.000000 | CCCR= | 0.0 | | |
| M= | 1.000000 | UEM= | 0.0 | CDEXP= | 0.0 | | |
| CF= | 1.000000 | Z1= | 463.000000 | CICER= | 0.000260 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.0 | Z3= | 27662.0000 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 22323.0000 | Z5= | 5339.00000 | Z6= | 0.0 |
| CALCULATED VALUES | | FLIGHT | | SUM TO 1.3.6 | | \$, MILLIONS | |
| CU=CCCR X (T X DF)XX(CDEXP) X CF | | | | | | 0.0 | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | | | 0.000 | |
| ORM =T / M | | | | | | 1.000 | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | | | 1.000 | |
| CTFU=(CLRM / E)X(ORM X (1+0.5)XX(E) -0.5XX(E)) | | | | | | 0.120 | |
| CTB =((CLRM/E)X((ORM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | |) / Z3 | | 0.000 | |
| CIPS=CTB*Z4/Z2 | | | | | | 0.097 | |
| CRC1 =CTB X R | | | | | | 0.0 | |
| PRE-IDC CRC1 =CRC1 X Z6 | | | | | | 0.0 | |
| POST-IDC CRC1 =CRC1 X (1.0-Z6) | | | | | | 0.0 | |
| CUEM =UEM OR C1E*Z5/Z2/ENVR | | | | | | 0.001 | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CCCR, CICER, AND UEM WERE | | | | 0.0 | 0.000222 | 0.0 | |

1.3.7 GROUND SUPPORT FACILITIES

This element includes all land, buildings, roads, shops, etc., required to support the cargo handling, launching, recovery, refurbishment, and operations of the space transportation system.

1.3.7.1 LAUNCH FACILITIES

This element includes the design and construction of the actual launch facility and its associated equipment. Included are land, buildings, and equipment required to support the various crews. It also includes the required control centers and administrative facilities.

1.3.7.2 RECOVERY FACILITIES

This element covers the design, construction, and equipping of the actual recovery facilities.

1.3.7.3 FUEL FACILITIES

This element includes fuel production facilities, storage and handling facilities, transportation, and delivery and safety facilities for both the fuel and the oxidizer. Also included are the facilities for fuels used in the various orbital transfer facilities.

1.3.7.4 LOGISTICS SUPPORT

This element includes the land, buildings, and handling equipment for the receiving, inspection, and storage and packaging of all payloads to be launched except for fuels and oxidizers.

1.3.7.5 OPERATIONS

This element includes the planning, development, and conduct of operations at the ground support facilities. It includes both the direct and support personnel and the expendable maintenance supplies required for the ground support facilities operation and maintenance.

A cost estimate for ground support facilities is projected in Table 1.3.7, based on the Boeing final report (NAS9-14710), dated September 1977, Volume 4, Cost Estimates. These costs have been escalated to 1979 dollars. It was judged that there is little difference in the cost of facilities in this report as compared with those projected for the transportation and operations requirements of this study.

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.3.7 GROUND SUPPORT FACILITIES

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|------------------|----------|------|-----------|--------------------|------------|-----|----------|
| T= | 1.000000 | TF= | 1.000000 | CDCER= | 2012.39990 | | |
| M= | 1.000000 | DEM= | 2.076749 | CDEXP= | 1.000000 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 3738.19015 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.001111 | Z3= | 3.000000 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 1.000000 | Z5= | 0.0 | Z6= | 0.816661 |

CALCULATED VALUES FACILITY SUM TO 1.3 \$, MILLIONS

CD=CDCER X (T X DF)XX(CDEXP) X CF 2012.400

CLRM=CICER X (M)XX(CIEXP) X CF X TF 3738.150

ERM = T / M 1.000

E = 1.0 + LOG(PHI) / LOG(2.0) 1.000

CTFU=(CLRM / E)X((ERM X Z1+0.5)XX(E) -0.5XX(E)) 3738.150

CTB =((CLRM/E)X((1/ERM X Z3 + 0.5)XX(E) -0.5XX(E))) / Z3 3738.148

CIPS=CTB*Z4/Z2 62.302

CRC1 =CTB X R 4.153

PRE-IOC CRC1 =CRC1 X Z6 3.392

POST-IOC CRC1 =CRC1 X (1.0-Z6) 0.761

CUEM =DEM OR CIB*Z5/Z2/ENVR 2.077

COMMENTS

1977 DATA ENTERED FOR CDCER, CICER, AND DEM WERE 1720.00000 3195.00000 1.7750/0
RC1 BASED ON EQUIVALENT OF 2 FACILITY REPLACEMENTS OVER PROGRAM INCLUDING DEM
DURING CONSTRUCTION. DEM COSTS BASED ON EQUIVALENT OF ONE FACILITY OVER PROGRAM.

1.4 GROUND RECEIVING STATION

The ground receiving station (GRS) is equivalent to the ground segment and is made up of elements including the rectenna, power conversion, power distribution, grid interface, and data management systems, plus land and facilities. The GRS is designed to accept microwave energy from a satellite and to convert that energy into electrical power for the utility. A typical receiving station would be located at 34°N latitude.

The GRS site for the reference satellite requires approximately 35,000 acres. The rectenna site for the magnetron associated site will increase to about 42,000 acres, while the siting requirement for the solid-state system is expected to be less than 20,000 acres. Figure 1.4-1 shows a layout of the Rockwell reference SPS site. The inner ellipse of 10x13 km contains 580,500 rectenna panels and is about 25,000 acres, or 72% of the total GRS acreage. The rectenna dimensions for the magnetron, end-mounted, and sandwich solid-state concept are 10.95 km x 14.34 km, 7.45 km x 9.76 km, and 4.87 km x 6.38 km, respectively. The area surrounding the inner ellipse is utilized for maintenance facilities, access roads, converter stations, and the two peripheral rows of towers which support the 40-kV dc and 500-kV ac cables. The outer perimeter of the area is fenced for security reasons. The towers which support the 500-kV ac cables are constructed of steel girders footed in concrete and are approximately 230 ft (70 m) high. The inner towers are each comprised for four tapered steel columns 60 ft (18.3 m) tall. Fifty-four of the larger towers and 401 of the smaller towers are required; the latter figure translating into 1604 tubular members because of the configuration.

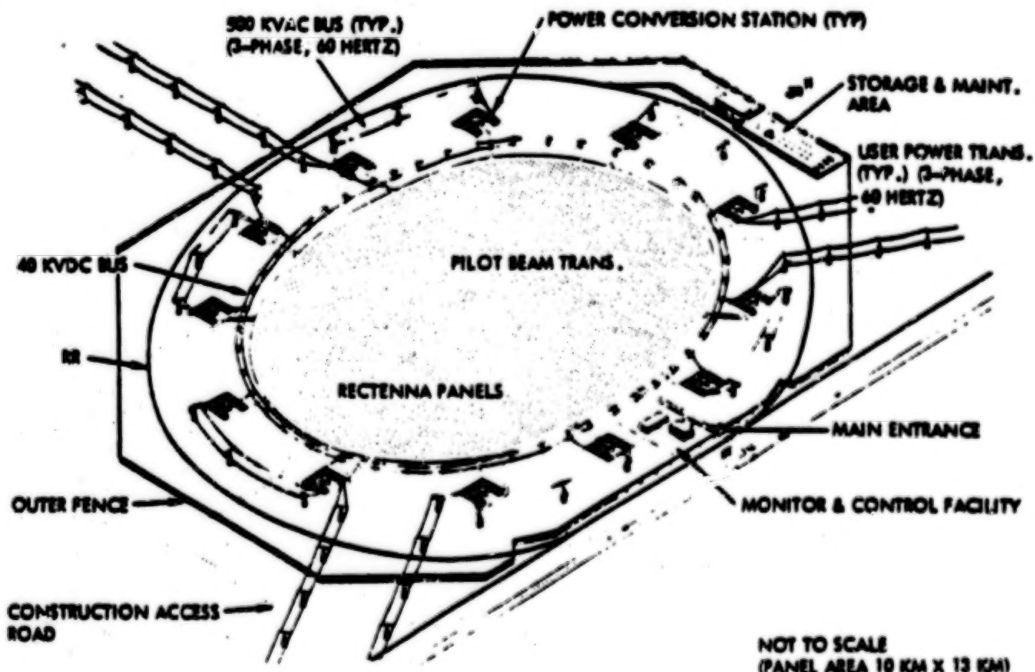


Figure 1.4-1. Operational Ground Receiving Facility (Rectenna)—Typical

Overall dimensions and area requirements for each of the five costed satellite configurations are summarized in Table 1.4-1. System point design characteristics for the klystron configuration are presented in Table 1.4-2.

Table 1.4-1. Ground Receiving Station Area Requirements

| | Klystron (Rockwell Reference) | Magnetron | Solid State (Dual End Mount) | Solid State GaAs | Sandwich GaAlAs/ GaAs |
|------------------------------|-------------------------------------|-------------|------------------------------------|---------------------|-----------------------------|
| Dimensions (km) | | | per Antenna | | |
| • Rectenna | 10×13 | 10.95×14.3 | 7.45×9.76 | 4.87×6.38 | 5.47×7.16 |
| • Perimeter | 12×15 | 12.4 × 16.3 | 8.44×11.06 | 10.06×13.18 | 11.29×14.79 |
| Land Area (km ²) | | | | | |
| • Rectenna | 102.1 | 123.0 | 57.11 | 24.4 | 30.76 |
| • Perimeter | 141.4 | 158.7 | 73.31 | 104.13 | 131.15 |
| Land Area (acres) | | | | | |
| • Rectenna | 25,000 | 30,000 | 14,000 | 6,000 | 7,600 |
| • Perimeter | 35,000 | 39,000 | 18,000 | 26,000 | 32,000 |

Table 1.4-2. Rockwell Reference System Point Design Characteristics

| | |
|---|---------------------|
| GRS size (km), 35,000 acres | 12×15 |
| Rectenna ground area (km ²), 25,000 acres | 102.1 |
| Rectenna panel area (km ²) | 79.53 |
| Area per panel (9.33×14.69 m) | 137.0 |
| Number of panels | 580,500 |
| Number of diodes | 330×10 ⁶ |
| Rectenna efficiency (%) | 88 |
| Voltage output per string (kV dc) | 40+ |
| Voltage output to utility (kV ac) | 500 |
| Power output (GW) at utility inter-tie | 5.07* |
| *Based upon 6.15 GW incident radiation. | |

The ground based element of the SPS is comprised of the land, facilities, equipment, and hardware/software systems to receive the radiated microwave power beam and to provide the power at the required voltage and type of current for entry into the national power grid. It also includes the equipment, facilities, and hardware/software necessary to provide operational control over the satellite; and a reliable means of monitoring and controlling ground based systems and equipment.

Major objectives of the SPS ground system design are: (1) to provide low maintenance subsystems and equipment capable of handling the designed power

levels; (2) to assure that the overall station will provide dependable service for at least 30 years; (3) to minimize the size of operational crews and costs; and (4) to economically optimize system performance.

There are nine major activities involved in the overall GRS construction process. After the survey and clearing, utilities and supporting facilities are installed while the site is leveled and graded. Trenching and concrete pouring precede the installation of rectenna panels, after which electrical hook-up, converter stations, and monitoring facilities are installed. The 40-kV dc and 500-kV ac buses are then interconnected and procedures take place for system checkout. Cost effective utilization of equipment and personnel was identified after the development and integration of detail phasing schedules on each of the first four ground stations. Contacts with A&E, equipment manufacturers, concrete, and construction firms provided additional information on the duration and sequence of operations based on their experience with programs of this type. Figure 1.4-2 is an integrated summary schedule of major events in constructing the ground receiving station where emphasis is placed on the utilization of construction equipments and their transfer from site to site as required to maintain the build rate of two stations per year. It was concluded that the equipment from Site 1 would be available for use on Site 3. This information on equipment/manpower utilization, site sequencing, and equipment lifetimes is used in this analysis to establish total resource requirements for the program.

The ground receiving station was divided into several main elements for the purpose of associating cost and programmatic definitions. These elements include (1) site and facilities, (2) rectenna support structure, (3) power collection, (4) control, (5) grid interface, and (6) operations. SPS design definitions and specification requirements were analyzed to provide realistic cost estimates and resource definitions for each element as explained in the following sections.

Internal Rockwell resources, cost estimating relationships, and other cost analyses were supplemented by (1) direct contact with business, industry, and institutional organizations, and (2) a literature search of various publications to obtain realistic cost estimates and operational definitions directly applicable to the unique requirements of the GRS. A list of principal organizations and literature sources are presented in Table 1.4-3.

A summary of costs associated with the Rockwell reference GRS is presented in Table 1.4-4. Detail supporting these costs is presented on subsequent pages of this section.

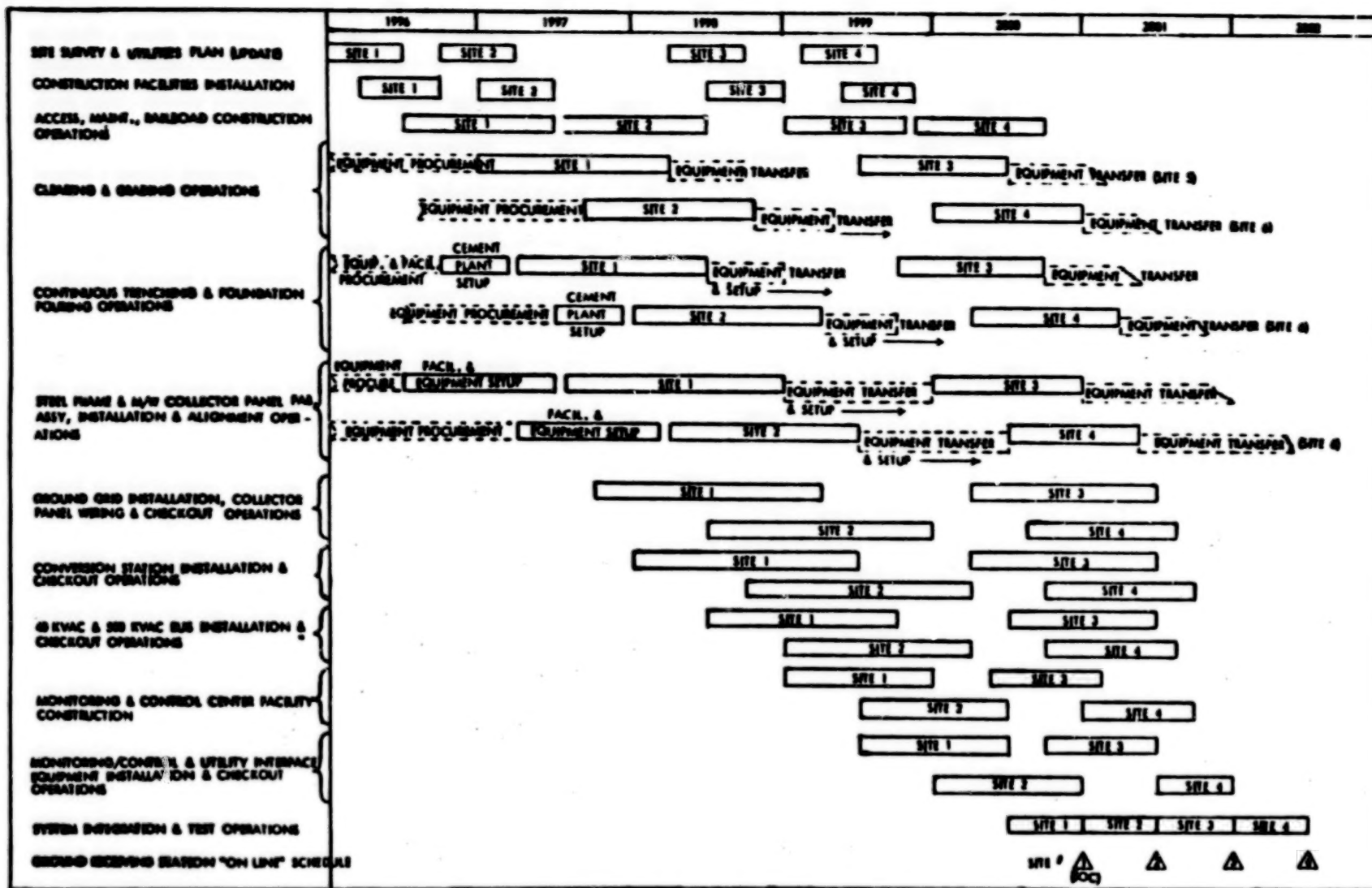


Figure 1.4-2. Rectenna Construction Sequence Summary Schedule

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Table 1.4-3. Organizations and Literature Sources Supporting GRS Definition

| ORGANIZATION | PURPOSE |
|--|--|
| <ul style="list-style-type: none"> • AMERICAN BRIDGE - A DIVISION OF U.S. STEEL | TO DEVELOP STEEL REQUIREMENTS, COSTS AND OPERATIONS DEFINITION FOR PROCUREMENT AND INSTALLATION OF RECTENNA SUPPORT STRUCTURE |
| <ul style="list-style-type: none"> • RIVERSIDE CEMENT - A DIVISION OF AMERICAN CEMENT CORPORATION; AND C. S. JOHNSON, CO. | PROVIDE CONSULTATION ON CEMENT/CONCRETE SPECIFICATIONS, OPERATIONAL METHODS, PROCESSING/HANDLING EQUIPMENT, AND CONCRETE PLANT |
| <ul style="list-style-type: none"> • TOWNSEND & BOTTUM, INC., CONSTRUCTION MANAGER, TEN MW SOLAR PLANT - BARSTOW, CA. | DISCUSS SITE PREPARATION, CONSTRUCTION OPERATIONS/SEQUENCING, PLUS ACTIVATION REQUIREMENTS |
| <ul style="list-style-type: none"> • SOUTHERN CALIFORNIA EDISON | TO DISCUSS DC/AC POWER DISTRIBUTION AND CONVERSION REQUIREMENTS, AND OBTAIN COST ESTIMATES ON INSTALLATION OF LINES/TOWERS |
| <ul style="list-style-type: none"> • MODERN ALLOYS, INC.; AND MILLER FORMLESS CO. | TO DISCUSS USE AND APPLICATION OF EQUIPMENT/CREW FOR CONTINUOUS CONCRETE POUR OF RECTENNA SUPPORT STRUCTURE FOOTINGS |
| <ul style="list-style-type: none"> • CATERPILLAR; INTERNATIONAL HARVESTER; AND JETCO, INC. | OBTAIN PRICES ON EARTH MOVING, GRADING AND TRENCHING EQUIPMENT |
| LITERATURE SOURCES | |
| <ul style="list-style-type: none"> • THE RICHARDSON RAPID SYSTEM 1978-1979 EDITION | CONSTRUCTION LABOR AND OPERATIONS PRICES |
| <ul style="list-style-type: none"> • ENGINEERING NEWS RECORD - 1977 A WEEKLY MCGRAW-HILL PUBLICATION | CEMENT, AGGREGATE AND LABOR PRICES |
| <ul style="list-style-type: none"> • NATIONAL CONSTRUCTION ESTIMATING GUIDE (NCE) | CONSTRUCTION OPERATIONS |

Table 1.4-4. GRS Cost Summary (1979 Dollars in Millions)

| WBS No. | Rockwell Reference Configuration | DDT&E | TFU | ICI | RCI/O&M (SAT/YR) | |
|---------|----------------------------------|-------|--------|--------|------------------|----------|
| | | | | | Pre-IOC | Post-IOC |
| 1.4.1 | Site and facilities | 1.2 | 228.4 | 221.0 | - | 0.3 |
| 1.4.2 | Rectenna support structure | 2.3 | 2164.2 | 2138.9 | 1.7 | - |
| 1.4.3 | Power collection | 3.5 | 1583.3 | 1583.2 | - | - |
| 1.4.4 | Control | 11.7 | 87.7 | 87.8 | - | - |
| 1.4.5 | Grid interface | 116.7 | 186.2 | 186.2 | - | - |
| 1.4.6 | Operations | - | - | - | - | 31.6 |
| | Total | 135.4 | 4249.8 | 4217.1 | 1.7 | 31.9 |

1.4.1 SITE AND FACILITIES

The ground receiving station is located on a site of 35,000 acres where over 25,000 acres of a central ellipse, or 72% of the total acreage, is used for rectenna panels. The area surrounding the inner ellipse is allocated for maintenance/control facilities, access roads, converter stations, and the rows of towers that support the 40 kW dc and 500 kV ac cables. The GRS perimeter is fenced for security reasons.

The sequence of construction operations begins with site identification, environmental impact studies, zoning/permits, surveys, utility/road installation, and supporting facilities. After reference coordinates are established, the site is cleared, leveled, and followed with precise grading for panel foundations, fabrication facilities, installation, and GRS site completion. This includes concrete mixing plants, rectenna panel fabrication factories, crew accommodations, warehousing, and support facilities as shown in Figure 1.4-3. The GRS DDT&E effort will be a valuable asset to all GRS sites by providing designs, analyses, and procurement specifications for commonly used buildings and facilities.

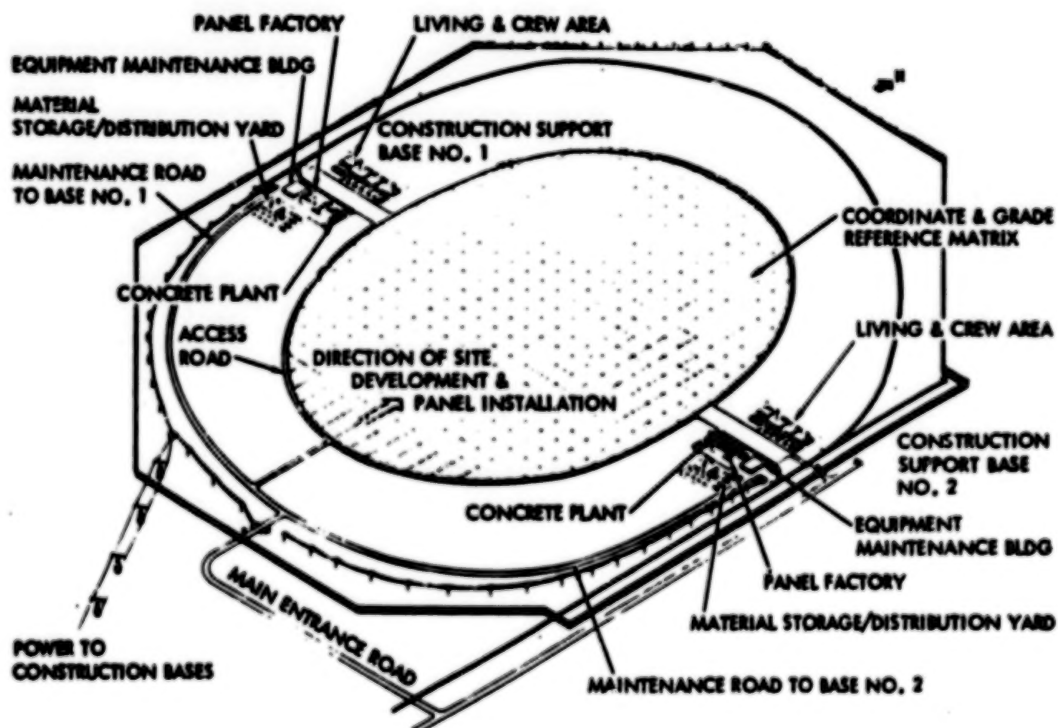


Figure 1.4-3. Support Facilities

Clearing and leveling operations will occur at a number of locations within the panel farm perimeter. These operations consist of tree removal (if required), grading, and leveling the terrain to acceptable slope angles, and removing excess dirt. Sixteen areas of the ellipse would be cleared and leveled simultaneously. Site topographics were assumed at a 1:30 maximum average grade of non-forested land. These ground rules lead to an appropriate identification of equipment.

Bulldozers will make the initial cut, scrapers will grade to more precise requirements, and an estimate was made of one crew of 13 men to grade eight acres per day. The crew and equipment required to prepare a 35,000-acre site were established based on a single shift that would level 130 acres per day to meet a nine-month schedule (reference contacts with heavy equipment distributors). A control center is envisioned for traffic monitoring and synchronized operations as the grading system moves through its operational sequencing. Contingencies for weather, shift changes, rest periods, etc., have been considered through the planning of a 20-hour day.

Costs developed for GRS site and facilities are divided into the elements of land, site preparation, roads and fence, utilities, buildings and facilities, maintenance equipment, lightning protection, and DDT&E. Basic design parameters used in this costing are presented in Table 1.4-5.

Table 1.4-5. Site and Facilities Requirements

| <u>Item</u> | <u>Unit Parameter</u> |
|----------------------|---|
| Land/fencing | 35,000 acres |
| Grading/leveling | Heavy equipment/crew size |
| Preparation | Survey, EIR, permits, A&E planning |
| Utilities | Water, electricity, gas, sewage |
| Roads/rails | Roads—35 miles, rails—45 miles |
| Facilities | Conversion station, monitor and control, maintenance/storage |
| Drainage | 6-in. gravel for combination access-way and drainage between panel rows |
| Lightning protection | TBD |

DDT&E, investment, and operations costs (1979 dollars) established for each element of site and facilities are presented in the following tables:

| <u>Category</u> | <u>Table</u> |
|-----------------------------|--|
| Land and Preparation | Land—1.4.1.1.1 Preparation—1.4.1.1.2 |
| Roads and Fences | Rails and Roads—1.4.1.2.1 Fencing—1.4.1.2.2 |
| Utilities | 1.4.1.3 |
| Buildings and Facilities | Storage/Maintenance—1.4.1.4.1 Converter Station—1.4.1.4.2 |
| Maintenance Equipment | 1.4.1.5 |
| Lightning Protection System | 1.4.1.6 |
| Site and Facilities DDT&E | 1.4.1.7 |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.4.1.1.1 LAND

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|------------|-------|----------------|--------------------|----------|-----|----------|
| T= | 35000.0000 | TF= | 1.000000 | CDCER= | 0.0 | | |
| M= | 35000.0000 | DEM= | 0.0 | CDEXP= | 0.0 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.001170 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.0 | Z3= | 60.000000 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 60.000000 | Z5= | 0.0 | Z6= | 1.000000 |
| CALCULATED VALUES | | ACRES | SUM TO 1.4.1.1 | S, MILLIONS | | | |
| CD=CDCER X (T X DF)XX(CDEXP) X CF | | | | 0.0 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 40.950 | | | |
| ORM =T / M | | | | 1.000 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 1.000 | | | |
| CTFU=(CLRM / E)X(ORM X Z1+0.5)XX(E) -0.5XX(E)) | | | | 40.950 | | | |
| CTB =((CLRM/E)X(ORM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | 1 / Z3 | 40.950 | | | |
| CIPS=CTB*Z4/Z2 | | | | 40.950 | | | |
| CRCI =CTB X R | | | | 0.0 | | | |
| PRE-IDC CRCI =CRCI X Z6 | | | | 0.0 | | | |
| POST-IDC CRCI =CRCI X (1.0-Z6) | | | | 0.0 | | | |
| COEM =DEM OR CTB*Z5/Z2/ENR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND DEM WERE | | | | 0.0 | 0.001000 | 0.0 | |
| RECTENNA 10 KM X 13 KM WITH BUFFER ZONE. | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980

TABLE 1.4.1.1.2 LAND PREPARATION

INPUT PARAMETERS

INPUT COEFFICIENTS

| | | | | | |
|------|------------|------|-----------|--------|----------|
| T= | 35000.0000 | TF= | 1.000000 | CDCER= | 0.0 |
| M= | 35000.0000 | UEM= | 0.0 | CDEXP= | 0.0 |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.002348 |
| PHI= | 0.980000 | Z2= | 60.000000 | CIEXP= | 1.000000 |
| R= | 0.0 | Z3= | 60.000000 | BYEAR= | 1979 |
| DF= | 1.000000 | Z4= | 60.000000 | Z5= | 0.0 |
| | | | | Z6= | 1.000000 |

CALCULATED VALUES

ACRES

SUM TO 1.4.1.1

8, MILLIONS

$$CD = CDCER \times (T \times DF) \times (CDEXP) \times CF$$

0.0

$$CLRM = CICER \times (M) \times (CIEXP) \times CF \times TF$$

82.187

$$ORM = T / M$$

1.000

$$E = 1.0 + \log(PHI) / \log(2.0)$$

0.971

$$CTFU = (CLRM / E) \times ((ORM \times Z1 + 0.5) \times (E) - 0.5 \times (E))$$

82.298

$$CTB = ((CLRM / E) \times ((ORM \times Z3 + 0.5) \times (E) - 0.5 \times (E)))$$

1 / Z3

75.019

$$CIPS = CTB \times Z4 / Z2$$

75.019

$$CRC1 = CTB \times R$$

0.0

$$PRE-10C \quad CRC1 = CRC1 \times Z6$$

0.0

$$POST-10C \quad CRC1 = CRC1 \times (1.0 - Z6)$$

0.0

$$COEM = OCM \text{ OR } CTB \times Z5 / Z2 / EWR$$

0.0

COMMENTS

1977 DATA ENTERED FOR CDCER, CICER, AND OCM WERE

0.0

0.002007

0.0

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.4.1.2.1 RAILS AND ROADS

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|----------|------|----------------|--------------------|-----------|--------|----------|
| T= | 1.000000 | TF= | 1.000000 | CDCER= | 0.0 | | |
| M= | 1.000000 | UEM= | 0.0 | CDEXP= | 0.0 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 86.240707 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.0 | Z3= | 60.000000 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 60.000000 | Z5= | 0.0 | Z6= | 1.000000 |
| CALCULATED VALUES | | SET | SUM TO 1.4.1.2 | S, MILLIONS | | | |
| CD=CDCER X (T X DF)XX(CDEXP) X CF | | | | 0.0 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 86.241 | | | |
| ORM =T / M | | | | 1.000 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 1.000 | | | |
| CTFU=(CLRM / E)X(ORM X Z1+0.5)XX(E) -0.5XX(E) | | | | 86.241 | | | |
| CTB =((CLRM/E)X(ORM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | | 1 / Z3 | | 86.241 | |
| CIPS=CTB*Z4/Z2 | | | | 86.241 | | | |
| CRCI =CTB X R | | | | 0.0 | | | |
| PRE-10C CRCI =CRCI X Z6 | | | | 0.0 | | | |
| POST-10C CRCI =CRCI X (1.0-Z6) | | | | 0.0 | | | |
| COEM =UEM OR CTB*Z5/Z2/ENYR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND OEM WERE 0.0 73.710007 0.0 | | | | | | | |
| ACCESS AND PERIMETER ROADS. GRAVEL ROADS AT RECTENNA ROWS. | | | | | | | |
| PERIMETER SPUR AND ACCESS RAILROAD. | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.4.1.2.2 FENCING

INPUT PARAMETERS

INPUT COEFFICIENTS

| | | | | | |
|------|------------|------|-----------|--------|----------|
| T= | 42671.0000 | TF= | 1.000000 | CDCER= | 0.0 |
| M= | 42671.0000 | DEM= | 0.0 | CDEXP= | 0.0 |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.000013 |
| PHI= | 0.980000 | Z2= | 60.000000 | CIEXP= | 1.000000 |
| R= | 0.0 | Z3= | 60.000000 | BYEAR= | 1979 |
| DF= | 1.000000 | Z4= | 60.000000 | Z5= | 0.0 |
| | | | | Z6= | 1.000000 |

CALCULATED VALUES

M

SUM TO 1.4.1.2

\$, MILLIONS

$$CD = CDCER \times (T \times DF) \times (CDEXP) \times CF$$

0.0

$$CLRM = CICER \times (M) \times (CIEXP) \times CF \times TF$$

0.549

$$BRM = T / M$$

1.000

$$E = 1.0 + \log(PHI) / \log(2.0)$$

0.971

$$CTFU = (CLRM / E) \times (BRM \times Z1 + 0.5) \times (E) - 0.5 \times (E)$$

0.550

$$CTB = ((CLRM / E) \times (BRM \times Z3 + 0.5) \times (E) - 0.5 \times (E))$$

1 / Z3

0.501

$$CIPS = CTB \times Z4 / Z2$$

0.501

$$CRC1 = CTB \times R$$

0.0

$$\text{PRE-10C } CRC1 = CRC1 \times Z6$$

0.0

$$\text{POST-10C } CRC1 = CRC1 \times (1.0 - Z6)$$

0.0

$$COEM = DEM \text{ OR } CTB \times Z5 / Z2 / ENYR$$

0.0

COMMENTS

1977 DATA ENTERED FOR CDCER, CICER, AND DEM WERE

0.0

0.000011

0.0

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.4.1.3 UTILITIES

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|----------|------|--------------|--------------------|----------|-----|----------|
| T= | 1.000000 | TF= | 1.000000 | CDCER= | 0.0 | | |
| M= | 1.000000 | UEM= | 0.0 | CDEXP= | 0.0 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.234000 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.0 | Z3= | 60.000000 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 60.000000 | Z5= | 0.0 | Z6= | 1.000000 |
| CALCULATED VALUES | | SET | SUM TO 1.4.1 | \$, MILLIONS | | | |
| CD=CDCER X (T X DF)XX(CDEXP) X CF | | | | 0.0 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 0.234 | | | |
| WRM = T / M | | | | 1.000 | | | |
| E = 1.0 + LOG(PHI) / LOG(2.0) | | | | 1.000 | | | |
| CTFU=(CLRM / E)X(WRM X Z1+0.5)XX(E) -0.5XX(E) | | | | 0.234 | | | |
| CTB = ((CLRM/E)X(WRM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | |) / Z3 | | | |
| CIPS=CTB*Z4/Z2 | | | | 0.234 | | | |
| CRC1 =CTB X R | | | | 0.0 | | | |
| PRE-IUC CRC1 =CRC1 X Z6 | | | | 0.0 | | | |
| POST-IUC CRC1 =CRC1 X (1.0-Z6) | | | | 0.0 | | | |
| COEM =UEM OR CTB*Z5/Z2/ENYR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND OEM WERE | | | | 0.0 | 0.200000 | 0.0 | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.4.1.4.1 STORAGE, MAINTENANCE FACILITIES

INPUT PARAMETERS

INPUT COEFFICIENTS

| | | | | | |
|------|----------|------|-----------|--------|----------|
| T= | 1.000000 | TF= | 1.000000 | CDCER= | 0.0 |
| M= | 1.000000 | UEM= | 0.0 | CDEXP= | 0.0 |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 1.521000 |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 1.000000 |
| R= | 0.0 | Z3= | 60.000000 | BYEAR= | 1979 |
| DF= | 1.000000 | Z4= | 60.000000 | Z5= | 0.0 |
| | | | | Z6= | 1.000000 |

CALCULATED VALUES

SUM TO 1.4.1.4

\$, MILLIONS

$$CD = CDCER \times (T \times DF) \times (CDEXP) \times CF$$

0.0

$$CLRM = CICER \times (M) \times (CIEXP) \times CF \times TF$$

1.521

$$E = T / M$$

1.000

$$E = 1.0 + \log(PHI) / \log(2.0)$$

1.000

$$CTFU = (CLRM / E) \times (1 + 0.5) \times (E) - 0.5 \times (E)$$

1.521

$$CTB = ((CLRM / E) \times (1 + 0.5) \times (E) - 0.5 \times (E)) \times 1 / Z3$$

1 / Z3

1.521

$$CIPS = CTB \times 24 / 22$$

1.521

$$CRC1 = CTB \times R$$

0.0

$$PRE-IOC \quad CRC1 = CRC1 \times Z6$$

0.0

$$POST-IOC \quad CRC1 = CRC1 \times (1.0 - Z6)$$

0.0

$$COEM = UEM \text{ OR } CTB \times Z5 / 22 / ENYR$$

0.0

COMMENTS

1977 DATA ENTERED FOR CDCER, CICER, AND UEM WERE

0.0

1.300000

0.0

ROCKWELL SFS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.4.1.4.2 UNV. STA. & MONITOR/CONTROL FAC.

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|------------|------|----------------|--------------------|----------|-----|----------|
| T= | 21290.0000 | TF= | 1.000000 | CDCER= | 0.0 | | |
| M= | 21290.0000 | UEM= | 0.0 | CDEXP= | 0.0 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.000559 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.0 | Z3= | 60.000000 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 60.000000 | Z5= | 0.0 | Z6= | 1.000000 |
| CALCULATED VALUES | | SQ M | SUM TO 1.4.1.4 | \$,MILLIONS | | | |
| CD=CDCER X (T X DF)XX(CDEXP) X CF | | | | 0.0 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 11.907 | | | |
| ORM =T / M | | | | 1.000 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 1.000 | | | |
| CTFU=(CLRM / E)X((ORM X (1+.5)XX(E) -0.5XX(E)) | | | | 11.907 | | | |
| CTB =((CLRM/E)X((ORM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | | 1 / Z3 | 11.907 | | |
| CIPS=CTB*24/22 | | | | 11.907 | | | |
| CRCI =CTB X R | | | | 0.0 | | | |
| PRE-IOC CRCI =CRCI X Z6 | | | | 0.0 | | | |
| POST-IOC CRCI =CRCI X (1.0-Z6) | | | | 0.0 | | | |
| CUEM =UEM OR CTB*25/22/ENYR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND UEM WERE | | | | 0.0 | 0.000478 | 0.0 | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.4.1.5 MAINTENANCE EQPT. FOR SITE & FACILITIES

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|----------|------|--------------|--------------------|----------|----------|-----|
| T= | 1.000000 | TF= | 1.000000 | CDCER= | 0.0 | | |
| M= | 1.000000 | UEM= | 0.093600 | CDEXP= | 0.0 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 4.680000 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.050000 | Z3= | 150.000000 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 60.000000 | 25= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | SET | SUM TO 1.4.1 | \$,MILLIONS | | | |
| CD=CDCER X (T X DF)XX(CDEXP) X CF | | | | 0.0 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 4.680 | | | |
| ORM =T / M | | | | 1.000 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 1.000 | | | |
| CTFU=(CLRM / E)X((ORM X Z1+.5)XX(E) -0.5XX(E)) | | | | 4.680 | | | |
| CTB =((CLRM/E)X((ORM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | |) / Z3 | | | |
| CIPS=CTB*Z4/Z2 | | | | 4.680 | | | |
| CRCI =CTB X R | | | | 0.234 | | | |
| PRE-IUC CRCI =CRCI X Z6 | | | | 0.0 | | | |
| PUST-IUC CRCI =CRCI X (1.0-Z6) | | | | 0.234 | | | |
| COEM =UEM OR CTB*Z5/Z2/ENYR | | | | 0.094 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND UEM WERE | | | | 0.0 | 4.000000 | 0.080000 | |
| MAINI. EQUIP., TOOLS, SITE, FOR MAINTENANCE OF RECTENNA. | | | | | | | |

ROCKWELL SPS LR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.4.1.6 LIGHTNING PROTECTION

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|----------|------|--------------|--------------------|-----|------|----------|
| T= | 0.0 | TF= | 1.000000 | CDCER= | 0.0 | | |
| M= | 0.0 | DEM= | 0.0 | CDEXP= | 0.0 | | |
| CF= | 0.0 | Z1= | 1.000000 | CICER= | 0.0 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 0.0 | | |
| R= | 0.0 | Z3= | 60.000000 | BYEAR= | | 1979 | |
| DF= | 1.000000 | Z4= | 60.000000 | Z5= | 0.0 | Z6= | 1.000000 |
| CALCULATED VALUES | | \$ | SUM TO 1.4.1 | \$, MILLIONS | | | |
| CD=CDCER X (T X DF)XX(CDEXP) X CF | | | | 0.0 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 0.0 | | | |
| ORM =T / M | | | | 0.0 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 0.0 | | | |
| CTFU=(CLRM / E)X(ORM X Z1+0.5)XX(E) -0.5XX(E) | | | | 0.0 | | | |
| CTB =(CLRM/E)X(ORM X Z3 + 0.5)XX(E) -0.5XX(E) | | | | 1 / Z3 0.0 | | | |
| CIPS=CTB*24/22 | | | | 0.0 | | | |
| CRCI =CTB X R | | | | 0.0 | | | |
| PRE-IDC CRCI =CRCI X Z6 | | | | 0.0 | | | |
| POST-IDC CRCI =CRCI X (1.0-Z6) | | | | 0.0 | | | |
| COEM =DEM OR CTB*25/22/ENYR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND DEM WERE | | | | 0.0 | 0.0 | 0.0 | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.4.1.7 SITE & FACILITIES DATA

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|---|----------|------|-----------|--------------------|----------|-----|----------|
| T= | 1.000000 | TF= | 1.000000 | CDCER= | 1.170000 | | |
| M= | 1.000000 | UGM= | 0.0 | CDEXP= | 1.000000 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.0 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 0.0 | | |
| R= | 0.0 | Z3= | 60.000000 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 60.000000 | Z5= | 0.0 | Z6= | 1.000000 |
| CALCULATED VALUES | | | | SUM TO 1.4.1 | | | |
| | | | | 8, MILLIONS | | | |
| CD=CDCER X (T X DF)XX(CDEXP) X CF | | | | 1.170 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 0.0 | | | |
| ORM =T / M | | | | 1.000 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 1.000 | | | |
| CTFU=(CLRM / E)X((ORM X Z1+.5)XX(E) -0.5XX(E)) | | | | 0.0 | | | |
| CTB =((CLRM/E)X((ORM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | |) / Z3 | | | |
| CIPS=CTB*Z4/Z2 | | | | 0.0 | | | |
| CRC1 =CTB X R | | | | 0.0 | | | |
| PRE-IOC CRC1 =CRC1 X Z6 | | | | 0.0 | | | |
| POST-IOC CRC1 =CRC1 X (1.0-Z6) | | | | 0.0 | | | |
| COIM =UGM OR CTB*Z5/Z2/ENYR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND UGM WERE 1.000000 0.0 0.0 | | | | | | | |

1.4.2 RECTENNA SUPPORT STRUCTURE

The rectenna farm area of 102.1 (km)^2 is covered by 580,500 panels that have a total mW intercept area of 79.53 (km)^2 . Each panel ($9.33 \text{ m} \times 14.69 \text{ m}$) is tilted at an angle of 40° to the horizontal and is mounted on two continuous ribbons of concrete as shown in Figure 1.4-4. Procurement, fabrication, assembly and installation of the steel rectenna support structure, and the placement of a supporting foundation are costed in this section and represent results of consultation and discussions with experienced individuals from industrial and construction organizations.

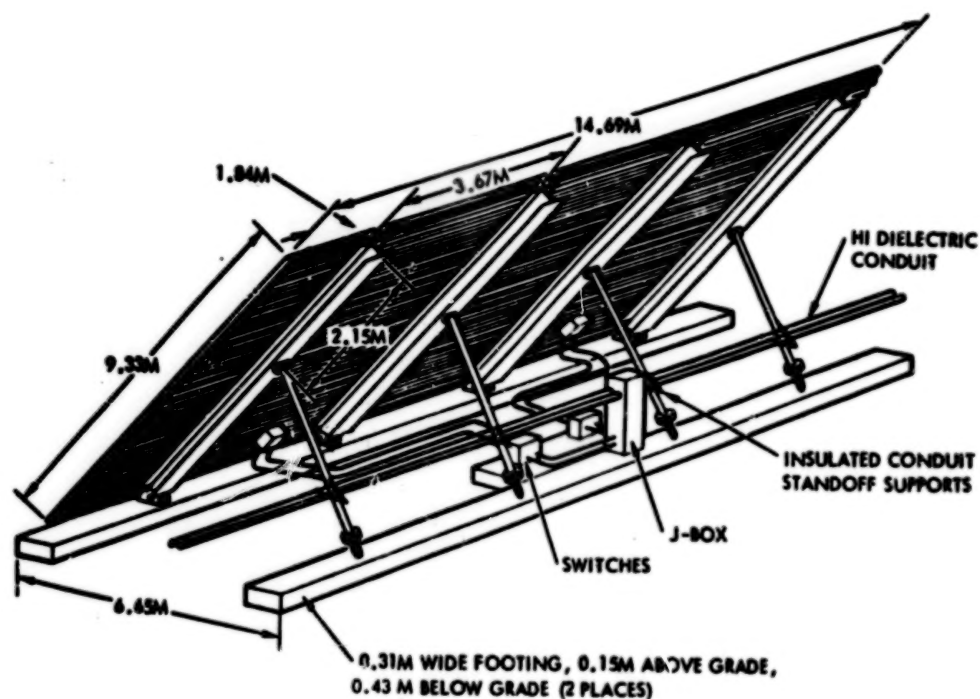


Figure 1.4-4. Panel Installation

1.4.2.1 PANEL STRUCTURE

The rectenna panel structure is comprised of four standard size eight-inch (wide flange) I beams, supporting tube braces, and 18 hat-shaped sections for the mounting of power collection electronic elements and the maintenance of panel rigidity. Tube braces, steel cast fittings and attachment hardware are used to support the panel on continuous footing as shown in Figure 1.4-5.

A detail analysis of the support structure was completed to identify the amount of material needed; necessary fabrication, operations, assembly, and installation requirements; and to estimate manpower and equipments needed to produce the average daily production requirement of 2150 panels over the nine-month period. The cost of processed materials for a rectenna panel is shown in 1.4-6.

The rectenna panel hat section serves as a mounting surface for the laminated-copper-clad mylar array elements. (See Section 1.4.3, Power Collection). Adhesives will be used to mount the elements to the structure to provide continuous support and added strength with a minimum of localized panel deflection.

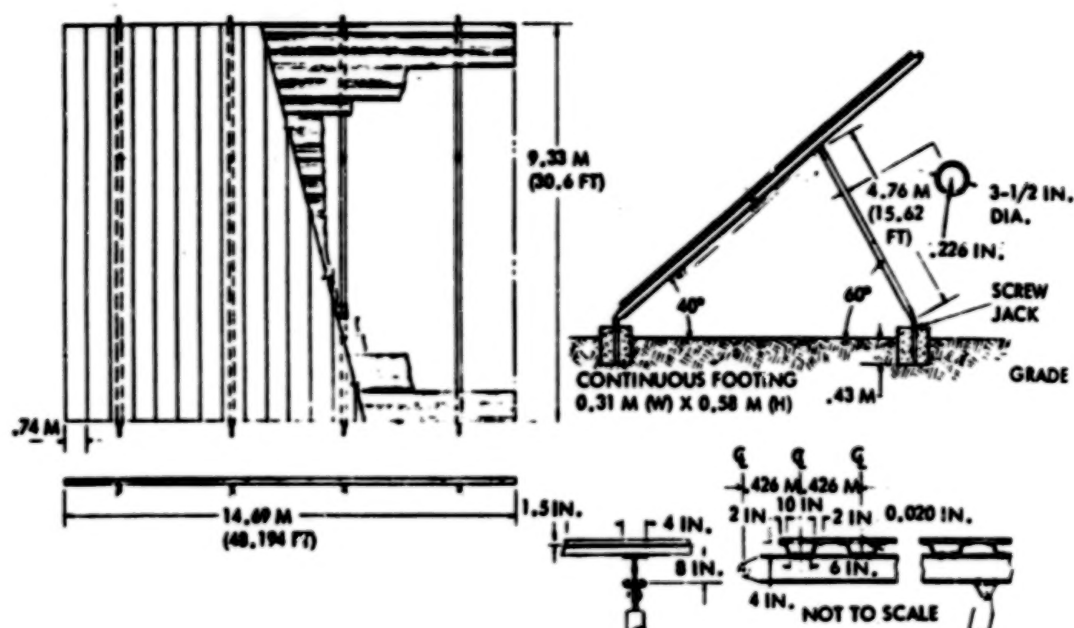


Figure 1.4-5. Rectenna Array Support Structure

| ITEM/DESCRIPTION | DIMENSIONAL DATA | NUMBER REQ'D | TOTAL WEIGHT | PREFAB & DELIVERED COST/PANEL * |
|---------------------------------|----------------------------------|--------------|---------------------|---------------------------------|
| HAT SECTIONS | 14.69M LONG 6" 4" 2" .020" | 18 | 1288# 584.25 kg | \$ 723.34 |
| I-BEAMS | 9.33M LONG 3.94" 7.90" 0.170" | 4 | 1589# 720.75 kg | \$ 594.92 |
| TUBE BRACES | 0.204 | 4 | | \$ 905.30 |
| HARDWARE FITTINGS & WELDING ROD | 4.76M LONG 0.226" 3.50" | 4 SETS | 1104# 500.75 kg | |
| RETURNED SCRAP ALLOWANCE | | | -307# -139 kg | \$ -35.92 |
| COST PER PANEL | | | 3674# 1666.75 kg | \$2187.64 |

*1979 dollars

Figure 1.4-6. Rectenna Panel Support Structure

The basic hat section is formed at the rectenna site from 0.020-inch galvanized steel sheet stock by processing through a set of forming rollers in a continuous manner. The forming machine (Yoder mill) accommodates widths of rolled mill stock sufficient to produce the finished hat sections ready for assembly to the I beams.

Four standard wide-flange 8-inch galvanized steel I-beams are required in lengths of 9.33 m for each rectenna panel. This material will be delivered to the site in pre-cut lengths for hole punching and the addition of brackets/machined castings for support braces and panel mounting.

Four 3.5-inch-diameter tube braces of galvanized steel are cut to a length of 4.76 m and preassembled to the fittings/hardware. Anchors, brackets, clips, hangers, etc., are fabricated or cast of carbon steel material and galvanized prior to machining at the site. All these items are scheduled to combine with the hat sections and I-beams at a centralized facility for assembly. A concept for such a facility is shown in Figure 1.4-7. The factory has multiple assembly lines where each line has a materials feed section, steel assembly facilities, electronics assembly and checkout section. It was assumed that one line using automated procedures could assemble and checkout a panel in 40 minutes. On this basis, seventy-two assembly lines operating 20 hours per day, seven days a week are required to produce 580,500 panels in the allocated 270 days.

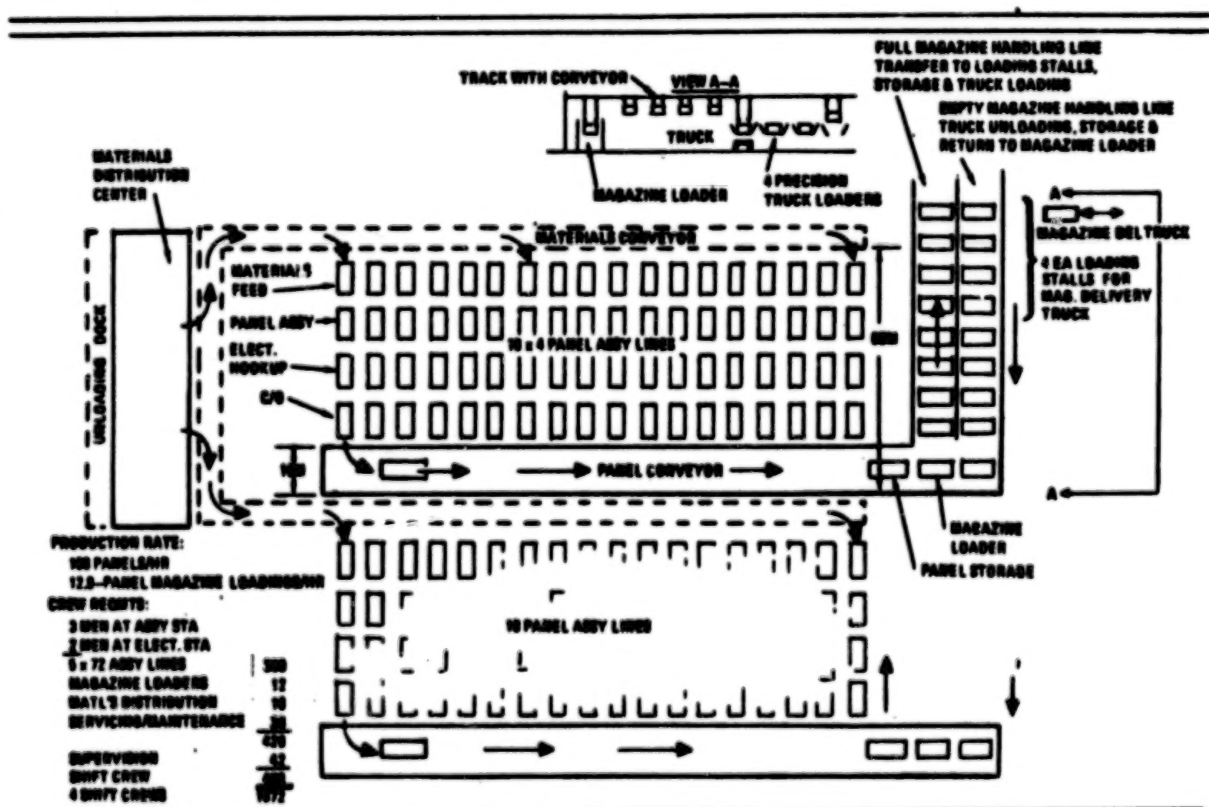


Figure 1.4-7. Central Panel Factory

After the panels have been checked, they are placed on an overhead conveying system and transported to loading stalls, where they are assembled into 9-panel magazines and loaded on specially designed trucks for delivery to the point of installation. Automated assembly and installation costs were estimated at \$1231 per panel.

Specialized equipment is required to deliver the panels from the factory to the installation point and to install them because of their large dimensions. After consultation with industrial sources on large equipment handling, a concept for a specialized machine was developed (Figure 1.4-8). The front and rear wheel pairs are each steerable as a unit and have provisions for height adjustment. The panels are transferred in magazines and lifted by means of fixtures mounted in vertical rails. They can be translated laterally and longitudinally for final positioning before attachment to the footings.

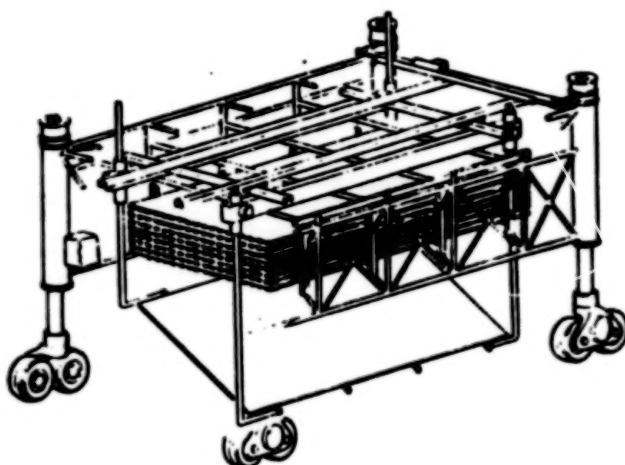


Figure 1.4-8. Panel Loading Sequence

1.4.2.2 TRENCHING AND CONCRETE FOOTINGS

A cost trade-off was made to consider eight individual footings versus continuous footings. A maximum wind force of 90 m/hr was assumed at rectenna panels mounted on the footings. It was determined that the amount of concrete required for either approach was essentially the same, but that the continuous footing concept was easier to install and required fewer operations and less capital equipment.

Each panel is secured to the footings at eight locations by fittings (brackets) which are imbedded in concrete during the pouring operation. Mounting attachments which provide for longitudinal and lateral adjustment are secured to the fittings. Screw jacks on each of the rear attach points provide for panel adjustment and alignment (reference Figure 1.4-5).

Table 1.4-6 summarizes costs of crew and equipment requirements for the placement of footings based on a nine-month schedule to prepare 1088 panel rows per rectenna.

Table 1.4-6. Concrete Footing Equipment/Crew

| ITEM/DESCRIPTION | SITE CONSTRUCTION QUANTITY | 1979 UNIT PRICES | TOTAL COST (1979 DOLLARS) |
|---|----------------------------------|------------------------|---------------------------------|
| TRENCHERS - JW-2 | 38 | \$81,900 | \$3,112,200 |
| DUMP TRUCKS - CAT 773 | 26 | \$409,500 | \$10,647,000 |
| CONCRETE DELIVERY VEHICLES - 10 C.Y. | 190 | \$58,500 | \$11,115,000 |
| CONCRETE FORMING MACHINES | 10 | \$70,200 | \$702,000 |
| CONCRETE CENTRAL MIX PAVING PLANTS | 2 | \$292,500 | \$585,000 |
| TOTAL COST | | | \$26,161,200 |
| TRENCHING & CONCRETE CREW PERSONNEL | 1480 | | |

The footings of continuous concrete are 0.43 meters deep, 0.31 meters wide, and project 0.15 meters above ground level. Two footings are excavated simultaneously by trenchers which feed the removed dirt into a truck. Approximately 17×10^6 meters of trenches must be excavated. To accomplish this, 38 trenchers are required, each trencher excavating 90 meters per hour. A well developed plan is contemplated by the placement of concrete footings in order to maximize labor requirements, avoid congestion, and improve operational sequences that deal with this highly repetitive activity on site after site.

Each rectenna panel will be mounted and aligned on 6.8 cu yds of concrete placed by concrete formers such as those commonly used in freeway divider construction. The formers extrude a shaped ribbon at rates of 6 meters per minute. Reinforcing steel and panel attach fittings are inserted as the concrete is vibrated during the extrusion process. Concrete footing requirements for rectenna panels are shown in Table 1.4-7.

1.4.2.3 COST ESTIMATES

DDT&E, investment, construction/installation, and operations costs of rectenna structures (less electronic elements) and the concrete footings needed to support these structures are identified in the following tables:

Rectenna Panel Fab. & Installation

Table 1.4.2.1.1 Hat Sections

Table 1.4.2.1.2 Wide Flanges

Table 1.4.2.1.3 Tube Braces & Hardware

Table 1.4-7. Concrete Footing Requirements per Panel

| ITEM/DESCRIPTION | 1979 \$ (MILL PRICE DELIVERED) | INGREDIENTS FOR 6.8 CU.YDS. | MATERIAL COST DELIVERED (1979 Dollars) |
|---|--------------------------------------|-----------------------------------|--|
| CEMENT (5 SACK) (94# SACK) | \$49.10/TON | 3196# | \$78.53 |
| SAND | \$5.28/TON | 9520# | \$25.12 |
| ROCK 1"-1½" | \$5.14/TON | 12444# | \$31.96 |
| WATER | - | 2040# | 0 |
| REINFORCING STEEL - #4 | \$0.12/LB | <u>64#</u> | \$7.53 |
| TOTAL/PANEL | | 27264# | |
| DELIVERED 1977 MILL PRICES PER ENGINEERING NEWS RECORD (ENR) - MCGRAW HILL, (AN INDUSTRY PUBLICATION) HAVE BEEN ESCALATED TO 1979 DOLLARS | | | |

Table 1.4.2.1.4 Assembly & Installation

Trenching and Concrete Installation

Table 1.4.2.2.1 Footing Concrete & Rebar

Table 1.4.2.2.2 Machinery & Equipment

Table 1.4.2.2.3 Construction Operations

Rectenna Panel DDT&E

Table 1.4.2.3 Support Structure DDT&E

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.4.2.1.1 MAT SECTIONS

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|---|------------|-------|----------------|--------------------|----------|-----|-----|
| T= | 580500.000 | TF= | 1.000000 | CDCER= | 0.0 | | |
| M= | 1.000000 | UEM= | 0.0 | COEXP= | 0.0 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.000724 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.0 | Z3= | 60.000000 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 60.000000 | Z5= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | PANEL | SUM TO 1.4.2.1 | \$ MILLIONS | | | |
| CD=CDCER X (T X DF)XX(COEXP) X CF | | | | 0.0 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 0.001 | | | |
| ORM =T / M | | | | 580500.000 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 1.000 | | | |
| CTFU=(CLRM / E)X((ORM X Z1+0.5)XX(E) -0.5XX(E)) | | | | 420.416 | | | |
| CTB =((CLRM/E)X((ORM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | | 1 / Z3 | 420.412 | | |
| CIPS=CTB*Z4/Z2 | | | | 420.412 | | | |
| CRC1 =CTB X R | | | | 0.0 | | | |
| PRE-IOC CRC1 =CRC1 X Z6 | | | | 0.0 | | | |
| POST-IOC CRC1 =CRC1 X (1.0-Z6) | | | | 0.0 | | | |
| COEM =UEM OR CTB*Z5/Z2/EMR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND UEM WERE 0.0 0.000619 0.0 | | | | | | | |
| EACH PANEL USES 18 MAT SECTIONS TOTALING 584.25 KG (1288 LBS) | | | | | | | |
| WITH COST ESTIMATE OF \$1.058/KG (\$4.8/LB). | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.4.2.1.2 WIDE FLANGES

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|------------|-------|----------------|--------------------|----------|-----|-----|
| T= | 580500.000 | TF= | 1.000000 | CDCER= | 0.0 | | |
| M= | 1.000000 | UGM= | 0.0 | CDEXP= | 0.0 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.000595 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.0 | Z3= | 60.000000 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 60.000000 | 25= | 0.0 | 26= | 0.0 |
| CALCULATED VALUES | | PANEL | SUM TO 1.4.2.1 | \$,MILLIONS | | | |
| CD=CDCER X (T X DF)XX(CDEXP) X CF | | | | 0.0 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 0.001 | | | |
| ARM =T / M | | | | 580500.000 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 1.000 | | | |
| CTFU=(CLRM / E)X((ARM X Z1+0.5)XX(E) -0.5XX(E)) | | | | 345.352 | | | |
| CTB =((CLRM/E)X((ARM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | | 1 / Z3 | 345.349 | | |
| CIPS=CTB*Z4/Z2 | | | | 345.349 | | | |
| CRC1 =CTB X R | | | | 0.0 | | | |
| PRE-IDC CRC1 =CRC1 X Z6 | | | | 0.0 | | | |
| POST-IDC CRC1 =CRC1 X (1.0-Z6) | | | | 0.0 | | | |
| UGM =UGM OR CTB*Z5/Z2/ENR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND UGM WERE | | | | 0.0 | 0.000508 | 0.0 | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.4.2.1.3 TUBE BRACES & HARDWARE

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|---|------------|-------|----------------|--------------------|----------|---------|-----|
| T= | 580500.000 | TF= | 1.000000 | CDCER= | 0.0 | | |
| M= | 1.000000 | DEM= | 0.0 | CDEXP= | 0.0 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.000869 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.0 | Z3= | 60.000000 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 60.000000 | Z5= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | PANEL | SUM TO 1.4.2.1 | \$,MILLIONS | | | |
| CD=CDCER X (1 X DF)XX(CDEXP) X CF | | | | 0.0 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 0.001 | | | |
| ORM =T / M | | | | 580500.000 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 1.000 | | | |
| CTFU=(CLRM / E)X((ORM X Z1+.5)XX(E) -0.5XX(E)) | | | | 504.675 | | | |
| CTB =((CLRM/E)X((ORM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | | 1 / Z3 | | 504.671 | |
| CIPS=CTB*Z4/Z2 | | | | 504.671 | | | |
| CRC1 =CTB X R | | | | 0.0 | | | |
| PRE-IOC CRC1 =CRC1 X Z6 | | | | 0.0 | | | |
| POST-IOC CRC1 =CRC1 X (1.0-Z6) | | | | 0.0 | | | |
| DEM =DEM OR CTB*Z5/Z2/ENVR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND DEM WERE 0.0 0.000743 0.0 | | | | | | | |
| INCLUDES 4 TUBE BRACES 4.76M LONG, | | | | | | | |
| FRONT & REAR CLEVIS FITTINGS, CAST MOUNTINGS, WELD ROD, | | | | | | | |
| AND PROVIDES FOR OVERALL SCRAP ALLOWANCES. | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.4.2.1.4 ASSEMBLY & INSTALLATION

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|------------|-------|----------------|--------------------|----------|-----|-----|
| T= | 580500.000 | TF= | 1.000000 | CDCER= | 0.0 | | |
| M= | 1.000000 | DEM= | 0.0 | CDEXP= | 0.0 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.001231 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.0 | Z3= | 60.000000 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 60.000000 | Z5= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | PANEL | SUM TO 1.4.2.1 | , MILLIONS | | | |
| CD=CDCER X (T X DF)XX(CDEXP) X CF | | | | 0.0 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 0.001 | | | |
| E = T / M | | | | 580500.000 | | | |
| E = 1.0 + LOG(PHI) / LOG(2.0) | | | | 1.000 | | | |
| CTFU=(CLRM / E)X(10RM X Z1+0.5)XX(E) -0.5XX(E) | | | | 714.591 | | | |
| CTB =((CLRM/E)X(10RM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | | 1 / Z3 | 714.585 | | |
| CIPS=CTB*Z4/Z2 | | | | 714.585 | | | |
| CRC1 =CTB X R | | | | 0.0 | | | |
| PRE-IOC CRC1 =CRC1 X Z6 | | | | 0.0 | | | |
| POST-IOC CRC1 =CRC1 X (1.0-Z6) | | | | 0.0 | | | |
| COEM =DEM OR CTR*Z5/Z2/E*YR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND DEM WERE | | | | 0.0 | 0.001052 | 0.0 | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.4.2.2.1 FLOATING CONCRETE & RE-BAR

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|------------|-------|----------------|--------------------|----------|-----|-----|
| T= | 580500.000 | TF= | 1.000000 | CDCER= | 0.0 | | |
| M= | 1.000000 | OEM= | 0.0 | CDEXP= | 0.0 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.000143 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.0 | Z3= | 60.000000 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 60.000000 | Z5= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | PANEL | SUM TO 1.4.2.2 | \$,MILLIONS | | | |
| CD=CDCER X (T X DF)XX(CDEXP) X CF | | | | 0.0 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 0.000 | | | |
| #RM =T / M | | | | 580500.000 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 1.000 | | | |
| CTFU=(CLRM / E)X((#RM X Z1+.5)XX(E) -0.5XX(E)) | | | | 82.861 | | | |
| CTB =((CLRM/E)X((#RM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | |) / Z3 82.860 | | | |
| CIPS=CTB*Z4/Z2 | | | | 82.860 | | | |
| CRC1 =CTB X R | | | | 0.0 | | | |
| PRE-IOC CRC1 =CRC1 X Z6 | | | | 0.0 | | | |
| POST-IOC CRC1 =CRC1 X (1.0-Z6) | | | | 0.0 | | | |
| COEM =OEM OR CTR*Z5/Z2/ENVR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER,CICER, AND OEM WERE 0.0 0.000122 0.0 | | | | | | | |
| CONCRETE ESTIMATED AT 6.8 CU YDS OF 5 SACK CEMENT. | | | | | | | |
| MIX 3196 LBS CEMENT, 9520 LBS SAND, | | | | | | | |
| 12444 LBS 1-1.5 INCH ROCK. | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.4.2.2.2 MACHINERY & EQUIPMENT - GRS CONSTRUCTION

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|---|----------|------|----------------|--------------------|-----------|-----|----------|
| T= | 1.000000 | TF= | 1.000000 | CDCER= | 0.0 | | |
| M= | 1.000000 | OEM= | 1.569673 | CDEXP= | 0.0 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 26.161194 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.003333 | Z3= | 8.000000 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 2.000000 | Z5= | 0.0 | Z6= | 1.000000 |
| CALCULATED VALUES | | SET | SUM TO 1.4.2.2 | \$,MILLIONS | | | |
| CD=CDCER X (T X DF)XX(CDEXP) X CF | | | | 0.0 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 26.161 | | | |
| E = T / M | | | | 1.000 | | | |
| E = 1.0 + LOG(PHI) / LOG(2.0) | | | | 1.000 | | | |
| CTFU=(CLRM / E)X((E X Z1+.5)XX(E) -0.5XX(E)) | | | | 26.161 | | | |
| CTB =((CLRM/E)X((E X Z3 + 0.5)XX(E) -0.5XX(E)) | | | |) / Z3 26.161 | | | |
| CIPS=CTB*Z4/Z2 | | | | 0.872 | | | |
| CRC1 =CTB X R | | | | 0.087 | | | |
| PRE-10C CRC1 =CRC1 X Z6 | | | | 0.087 | | | |
| POST-10C CRC1 =CRC1 X (1.0-Z6) | | | | 0.0 | | | |
| COEM =OEM OR CTR*Z5/Z2/E*NYR | | | | 1.570 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND OEM WERE 0.0 22.360001 1.341600 | | | | | | | |
| HEAVY DUTY EQUIPMENT. 2 SETS FOR SEQUENCED CONSTRUCTION. RC1 SETS | | | | | | | |
| THREE TIMES OVER 30 YEAR PERIOD. 71/2 YEAR LIFE WITH MAINTENANCE. | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.4.2.2.3 CONSTRUCTION OPERATIONS

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|------------|---------|-----------|--------------------|----------|-------------|----------|
| T= | 399600.000 | TF= | 1.000000 | CDCER= | 0.0 | | |
| M= | 399600.000 | OGM= | 0.0 | CDEXP= | 0.0 | | |
| LF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.000176 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.0 | Z3= | 60.000000 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 60.000000 | Z5= | 0.0 | Z6= | 1.000000 |
| CALCULATED VALUES | | MANDAYS | | SUM TO 1.4.2.2 | | \$ MILLIONS | |
| CD=CDCER X (T X DF)XX(CDEXP) X CF | | | | 0.0 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 70.130 | | | |
| WRM =T / M | | | | 1.000 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 1.000 | | | |
| CTFU=(CLRM / E)X((WRM X Z1+.5)XX(E) -0.5XX(E)) | | | | 70.130 | | | |
| CTB =(CLRM/E)X((WRM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | |) / Z3 | | 70.130 | |
| CIPS=CTB*Z4/Z2 | | | | 70.130 | | | |
| CRCI =CTB X R | | | | 0.0 | | | |
| PRE-IOC CRCI =CRCI X Z6 | | | | 0.0 | | | |
| POST-IOC CRCI =CRCI X (1.0-Z6) | | | | 0.0 | | | |
| COGM =OGM OR CTB*Z5/Z2/ENYR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND OGM WERE | | | | 0.0 | 0.000150 | 0.0 | |
| 270 WORK DAYS FOR CREW OF 1480 | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.4.2.3 SUPPORT STRUCTURE DOT&E

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|----------|------|--------------|--------------------|--------------|-----|-----|
| T= | 1.000000 | TF= | 1.000000 | CDCER= | 2.340000 | | |
| M= | 1.000000 | UEM= | 0.0 | CDEXP= | 0.300000 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.0 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 0.0 | | |
| R= | 0.0 | Z3= | 60.000000 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 60.000000 | Z5= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | SET | SUM TO 1.4.2 | | \$, MILLIONS | | |
| CD=CDCER X (T X DF)XX(CDEXP) X CF | | | | | 2.340 | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | | 0.0 | | |
| ORM = T / M | | | | | 1.000 | | |
| E = 1.0 + LOG(PHI) / LOG(2.0) | | | | | 1.000 | | |
| CTFU=(CLRM / E)X((ORM X Z1+.5)XX(E) -0.5XX(E)) | | | | | 0.0 | | |
| CTB =(CLRM/E)X((ORM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | 1 / Z3 | | 0.0 | | |
| CIPS=CTB*Z4/Z2 | | | | | 0.0 | | |
| CRCI =CTB X R | | | | | 0.0 | | |
| PRE-IOC CRCI =CRCI X Z6 | | | | | 0.0 | | |
| POST-IOC CRCI =CRCI X (1.0-Z6) | | | | | 0.0 | | |
| CUEM =UEM OR CTB*Z5/Z2/ENYX | | | | | 0.0 | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDLER, CICER, AND OEM WERE | | | | 2.000000 | 0.0 | 0.0 | |

1.4.3 POWER COLLECTION

This element of the GRS includes rectenna array elements associated with the actual reception and rectification of microwave energy. These array elements are in series and parallel as required to deliver the line output voltage and current. Also included are those components that accept dc power from array elements and route, control, convert, and switch this power for delivery to power conversion stations of the grid interface.

Incident microwave energy from the satellite is estimated to total 6.15 GW within an elliptical area with major and minor axes of 13 km and 10 km, respectively. The rectenna area is arbitrarily divided into five concentric zones, with power received per unit area diminishing from the center to the edge. Figure 1.4-9 shows these zones plotted for the 10x13-km (reference) rectenna, along with some of the other assumed rectenna characteristics.

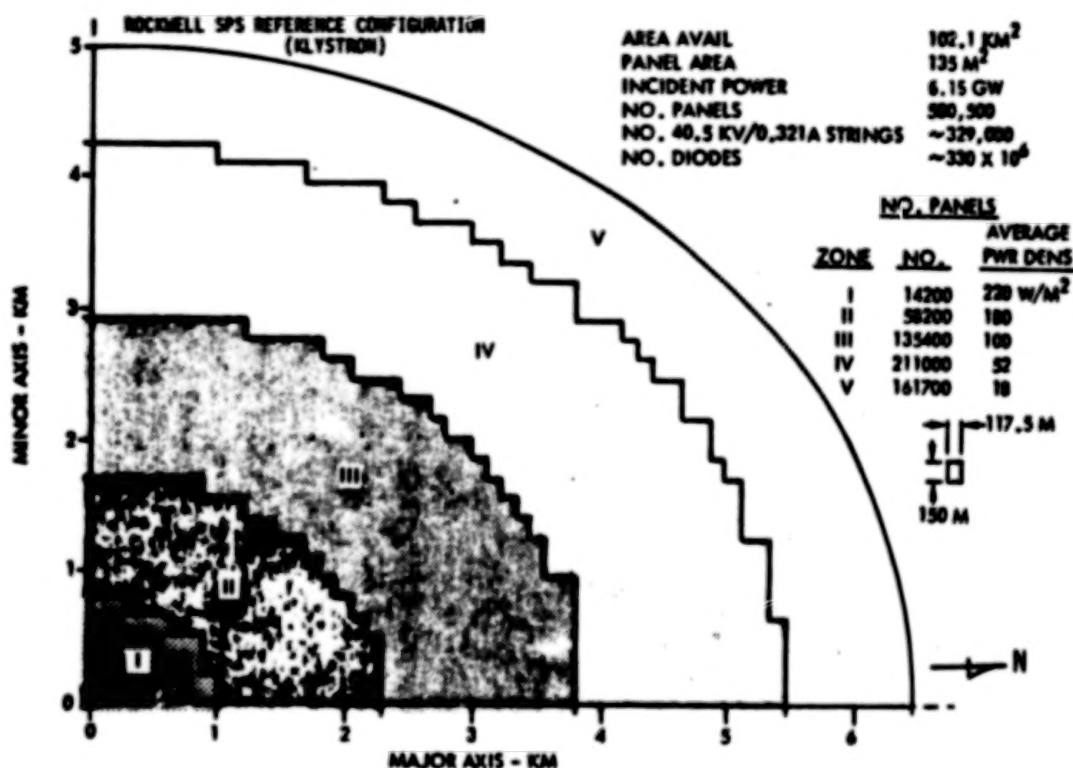


Figure 1.4-9. Rectenna Power Density Pattern (34°N Latitude)

Rectifier assemblies (rectenna panel electronics) consist of GaAs diodes and input/output filters. The outputs of these circuits are series connected to produce outputs of 40 kV as shown in Figure 1.4-10. Power regulation equipment accepts voltage from the series connected rectenna diodes and adjusts voltage outputs to power distribution feeders at values consistent with a positive current flow. Rectenna array elements are 0.735x9.33 m in size, and 20 elements are combined per panel with diode circuitry equivalent to the microwave density pattern. A total of 735 diodes or diode equivalents are required per average panel with a rectenna total of 330x10⁶ diodes as shown in Figure 1.4-11.

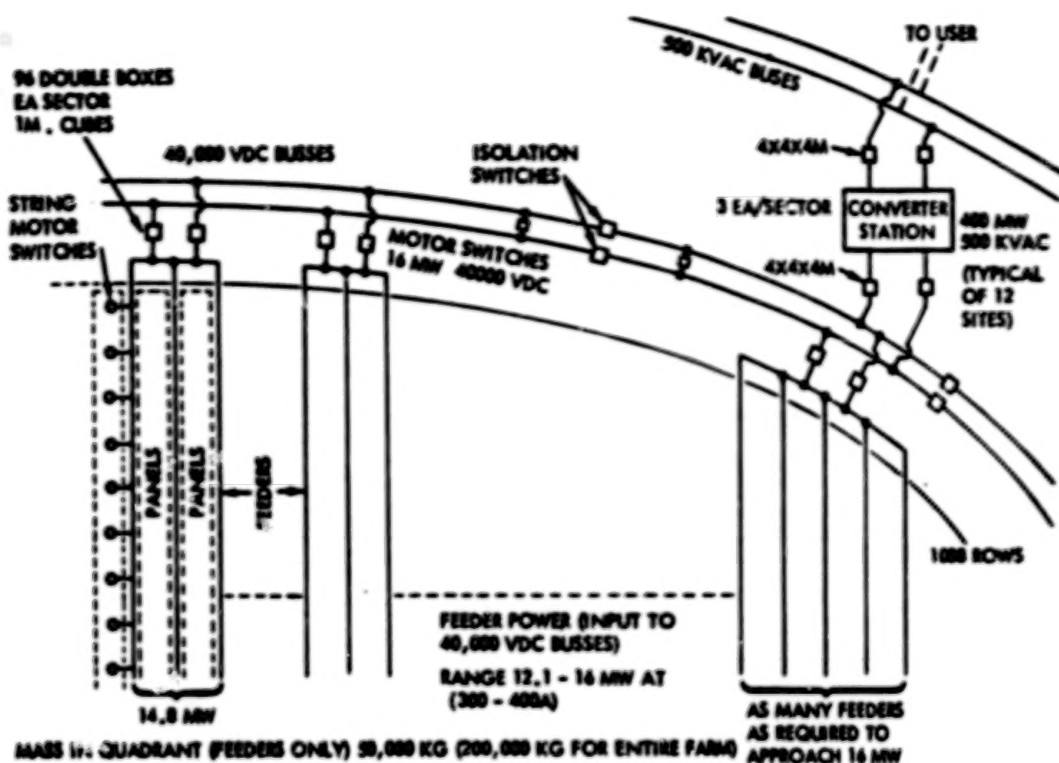


Figure 1.4-10. Rectenna Schematic Block Diagram
(Preliminary)

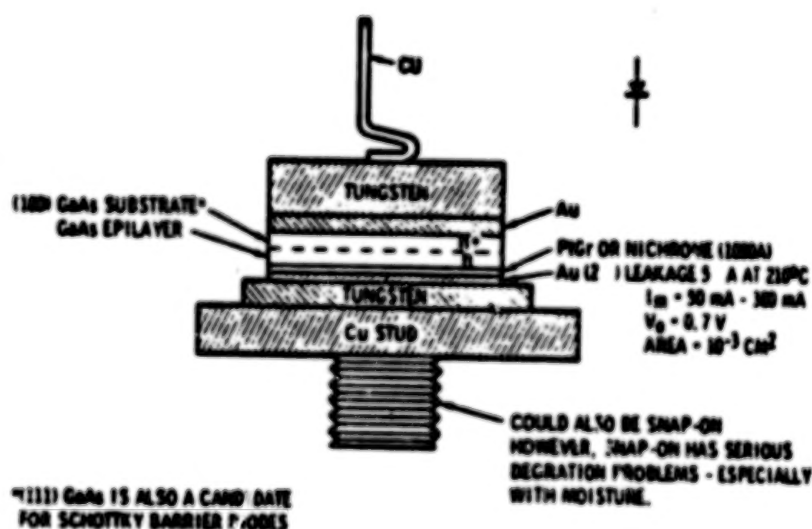
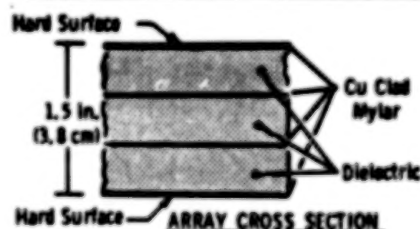


Figure 1.4-11. Diode Concept

Electronic array elements of the antenna are multilayered copper/dielectric sandwich panel material. Resource/mass projections are identified in Figure 1.4-12 based on the array cross section and panel requirements shown in the illustration. Costs were then determined from estimating guides/industrial contacts to provide a cost estimate of $\$1088 \times 10^6$ for all antenna array elements (Table 1.4-8). The addition of costs for switches and regulators needed at each panel provides a cost estimate of $\$2272/\text{panel}$.

| 500,500 RECTENNA PANELS | | |
|---|---|---------------------------------|
| • <u>DIELECTRIC</u> | | |
| PLASTIC COMPOUND— 3.5 LB/FT^3 , $0.4375 \text{ LB/FT}^2 \times 856.4 \times 10^6 \text{ FT}^2$ | - | $374.68 \times 10^6 \text{ LB}$ |
| • <u>MYLAR</u> | | |
| 0.001-IN. THICKNESS AT 87.36 LB/FT^3 , $0.02913 \text{ LB/FT}^2 \times 856.4 \times 10^6 \text{ FT}^2$ | - | $24.95 \times 10^6 \text{ LB}$ |
| • <u>COPPER</u> | | |
| 0.0039 THICKNESS AT 556.6 LB/FT^3 , $0.118753 \text{ LB/FT}^2 \times 856.4 \times 10^6 \text{ FT}^2$ | - | $101.70 \times 10^6 \text{ LB}$ |
| • <u>DIODES</u> | | |
| 1 OZ. PER 426.67×10^6 DIODES OR EQUIV. - | | $26.67 \times 10^6 \text{ LB}$ |
| TOTAL | | $528 \times 10^6 \text{ LB}$ |
| | | 909.6 LB/PANEL |
| | | 412.6 KG/PANEL |



- 20 ARRAY ELEMENTS/PANEL
- 1475 FT^2 (137 M^2) PER PANEL
- 1980 TECHNOLOGY
- 1977 PRICES

Figure 1.4-12. Resource Requirements Rectenna Dipole
—Bow-Tie—Panel Array Elements

The power collection and distribution system consists of all field feeders (collectors), supporting switch gear, 40-kV dc buses to the power converters, and the towers/footings needed to support the transmission lines. Approximately 330,000 switch gears, 10^7 meters of feeder cables, miscellaneous junction boxes, etc., must be delivered and installed at the panel sites. Tractor/trailer trucks are used for this purpose and proceed through the panel rows, delivering material at each panel. Additional trucks with reels play out the feeders, which then are installed in conduits and spliced to panel connections by the electrical installation crew. Contacts with a utility company indicate a requirement of eight man-hours to hook up one panel. On this basis, the manpower and equipment projections were established for a 20-hour 7-day week.

Equipment for electrical hookup and checkout of completed panels was calculated on the basis of acquisition cost prorated over the service life and

utilization period at a particular site. Total crew requirements of 4196 personnel and the schedule period were the basis of calculating man-day requirements of 755,280. The amortized cost of equipment and labor was combined for the total cost factor.

Table 1.4-8. Rectangular Dipole—Bow-Tie—
Panel Array Elements

| | |
|--------------------------------------|--|
| • Total panel area: | $9.33 \text{ m} \times 14.69 \text{ m} \times 580,500 \text{ panels} = 79.56 \times 10^6 \text{ m}^2$ ($30.61 \text{ ft} \times 48.19 \text{ ft} \times 580,500 \text{ panels} = 856.4 \times 10^6 \text{ ft}^2$) |
| • Dielectric: | $0.4375 \text{ lb/ft}^2 \times 856.4 \times 10^6 \text{ ft}^2 @ \$1.02/\text{lb} = \$382.27 \times 10^6$ |
| • Mylar/surface: | $4 \text{ layers} \times 856.4 \times 10^6 \text{ ft}^2 @ \$0.117/\text{ft}^2 = \$400.80 \times 10^6$ |
| • Copper (processed/bonded): | $65\% \text{ coverage } 856.4 \times 10^6 \text{ ft}^2 @ \$0.175/\text{ft}^2 = \$97.69 \times 10^6$ |
| • Diodes/equivalents/wire: | $426.67 \times 10^6 \text{ diodes @ } \$0.117 \text{ each} = \$49.92 \times 10^6$ |
| • Bonding: | $6 \text{ surfaces } 856.4 \times 10^6 \text{ ft}^2 @ \$0.0307/\text{ft}^2 = \$157.51 \times 10^6$ |
| (1979 Dollars) Total panel area cost | $\$1088.19 \times 10^6$ (\$1874.57/panel) |

DDT&E power collection costs are associated with the design and verification of bow-tie electronic panels/bonding processes, connectors, and large switch gear to optimize the voltage/current ratios and element/wiring configuration. Cost estimates are provided in the following areas:

| Area | Table |
|---------------------------|---------|
| Antenna Array Elements | 1.4.3.1 |
| Power Distribution System | 1.4.3.2 |
| Installation and Checkout | 1.4.3.3 |
| Power Collection DDT&E | 1.4.3.4 |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.4.3.1 ANTENNA ARRAY ELEMENTS

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|---|------------|-------|--------------|--------------------|----------|-----|-----|
| T= | 580500.000 | TF= | 1.000000 | CDL= | 0.0 | | |
| M= | 1.000000 | DEM= | 0.0 | CDEXP= | 0.0 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CIC= | 0.002272 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.0 | Z3= | 60.000000 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 60.000000 | 25= | 0.0 | 26= | 0.0 |
| CALCULATED VALUES | | PANEL | SUM TO 1.4.3 | \$, MILLIONS | | | |
| CU=CDL X (T X DF)XX(CDEXP) X CF | | | | 0.0 | | | |
| CLRM=CIC X (M)XX(CIEXP) X CF X TF | | | | 0.002 | | | |
| DRM = T / M | | | | 580500.000 | | | |
| E = 1.0 + LOG(PHI) / LOG(2.0) | | | | 1.000 | | | |
| CTFU=(CLRM / E)X((DRM X Z1+0.5)XX(E) -0.5XX(E)) | | | | 1318.978 | | | |
| CTB = ((CLRM/E)X((DRM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | 1 / Z3 | 1318.967 | | | |
| CIPS=CTB*24/22 | | | | 1318.966 | | | |
| CRC1 =CTB X R | | | | 0.0 | | | |
| PRE-IDC CRC1 =CRC1 X Z6 | | | | 0.0 | | | |
| POST-IDC CRC1 =CRC1 X (1.0-Z6) | | | | 0.0 | | | |
| COEM =DEM OR CTB*25/22/ENYR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDL, CIC, AND DEM WERE | | | | 0.0 | 0.001942 | 0.0 | |

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ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.4.3.2 POWER DISTRIBUTION SYSTEM

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|------------|-------|--------------|--------------------|----------|-----|-----|
| T= | 580500.000 | TF= | 1.000000 | CDCER= | 0.0 | | |
| M= | 1.000000 | UEM= | 0.0 | CDEXP= | 0.0 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.000140 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.0 | Z3= | 60.000000 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 60.000000 | Z5= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | PANEL | SUM TO 1.4.3 | \$,MILLIONS | | | |
| CD=CDCER X (T X DF)XX(CDEXP) X CF | | | | 0.0 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 0.000 | | | |
| ARM =T / M | | | | 580500.000 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 1.000 | | | |
| CTFU=(CLRM / E)X((ARM X Z1+.5)XX(E) -0.5XX(E)) | | | | 81.502 | | | |
| CTB =(CLRM/E)X((ARM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | |) / Z3 81.501 | | | |
| CIPS=CTB*Z4/Z2 | | | | 81.501 | | | |
| CRC1 =CTB X R | | | | 0.0 | | | |
| PRE-IUC CRC1 =CRC1 X Z6 | | | | 0.0 | | | |
| POST-IUC CRC1 =CRC1 X (1.0-Z6) | | | | 0.0 | | | |
| COEM =UEM OR CTB*Z5/Z2/ENYR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDLER, CICER, AND OEM WERE | | | | 0.0 | 0.000120 | 0.0 | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.4.3.3 INSTALLATION & CHECKOUT

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|------------|---------|--------------|--------------------|----------|-----|-----|
| T= | 781100.000 | TF= | 1.000000 | CDCER= | 0.0 | | |
| M= | 4340.00000 | OEM= | 0.0 | CDEXP= | 0.0 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.000234 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.0 | Z3= | 60.000000 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 60.000000 | Z5= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | MANDAYS | SUM TO 1.4.3 | \$ MILLIONS | | | |
| CD=CDCER X (T X DF)XX(CDEXP) X CF | | | | 0.0 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 1.016 | | | |
| ORM =T / M | | | | 179.977 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 1.000 | | | |
| CTFU=(CLRM / E)X((ORM X Z1+.5)XX(E) -0.5XX(E)) | | | | 182.777 | | | |
| CTB =((CLRM/E)X((ORM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | | 1 / Z3 | 182.777 | | |
| CIPS=CTB*Z4/Z2 | | | | 182.777 | | | |
| CRC1 =CTB X R | | | | 0.0 | | | |
| PRE-IDC CRC1 =CRC1 X Z6 | | | | 0.0 | | | |
| POST-IDC CRC1 =CRC1 X (1.0-Z6) | | | | 0.0 | | | |
| COEM =OEM OR CTB*Z5/Z2/ENYR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND OEM WERE | | | | 0.0 | 0.000200 | 0.0 | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.4.3.4 POWER COLLECTION-DDT&E

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|---|----------|------|--------------|--------------------|----------|-----|-----|
| T= | 1.000000 | TF= | 1.000000 | CDCER= | 3.510000 | | |
| M= | 1.000000 | DEM= | 0.0 | CDEXP= | 0.300000 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.0 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 0.0 | | |
| R= | 0.0 | Z3= | 60.000000 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 60.000000 | 25= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | SET | SUM TO 1.4.3 | \$,MILLIONS | | | |
| CD=CDCER X (T X DF)XX(CDEXP) X CF | | | | 3.510 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 0.0 | | | |
| ORM =T / M | | | | 1.000 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 1.000 | | | |
| CTFN=(CLRM / E)X((ORM X Z1+.5)XX(E) -0.5XX(E)) | | | | 0.0 | | | |
| CTB =(CLRM/E)X((ORM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | |) / Z3 | | | |
| CIPS=CTB*Z4/Z2 | | | | 0.0 | | | |
| CRCI =CTB X R | | | | 0.0 | | | |
| PRE-IUC CRCI =CRCI X Z6 | | | | 0.0 | | | |
| POST-IUC CRCI =CRCI X (1.0-Z6) | | | | 0.0 | | | |
| OCM =OCM UR CTB*Z5/Z2/EMR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER,CLER, AND OCM WERE | | | | 3.000000 | 0.0 | 0.0 | |

1.4.4 CONTROL

The telemetry, tracking, communications, monitoring of microwave beam characteristics, computing phase corrections, and the equipment needed to provide frequency standard signals for the satellite are included in this section. This hardware will be used to monitor and control the satellite from the ground.

The following monitor and control functions are performed:

1. Tracking, using ground-based radars to monitor the orbital stability of the satellite.
2. Beam monitoring and control, using ground equipment for adaptive or command control of the satellite microwave beam.
3. Data management, using equipment required to analyze signals and data from the satellite and ground-based systems to compute control signals and corrective data to maintain safe and optimum performance.
4. Communications, using equipment required to maintain communications between the ground station and the SPS satellite. Included are the communications with the crew, and telemetry and command equipment not included in the beam monitoring and control assembly.

At this time, the cost effort is divided into the three categories of control center equipment, beam control electronics, and DDT&E. Two sets of full-up IBM 370, or equivalents, a complete display center, and a manned control room are envisioned as basic elements of the control center. Beam control electronics would consist of control sensors and dual frequency transmitters. The overall DDT&E and hardware costs were projected by engineering. The exacting requirement of this rectenna operation will require further study in future contract activity to define the technical and performance standards. It should also be noted that system and operational requirements are needed to define adequate software/programming considerations.

Cost estimates are presented as follows:

Table 1.4.4.1 Control Center Equipment

Table 1.4.4.2 Control Electronics

Table 1.4.4.3 Control DDT&E

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.4.4.1 CONTROL CENTER EQUIPMENT

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|----------|-----|--------------|--------------------|-----------|-----|-----|
| T= | 1.000000 | TF= | 1.000000 | CDCER= | 0.0 | | |
| M= | 1.000000 | GM= | 0.0 | COEXP= | 0.0 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 17.549988 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.0 | Z3= | 60.000000 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 60.000000 | Z5= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | SET | SUM TO 1.4.4 | \$,MILLIONS | | | |
| CD=CDCER X (T X DF)XX(COEXP) X CF | | | | 0.0 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 17.550 | | | |
| ORM =T / M | | | | 1.000 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 1.000 | | | |
| CTFU=(CLRM / E)X((ORM X Z1+.5)XX(E) -0.5XX(E)) | | | | 17.550 | | | |
| CTB =1(CLRM/E)X((ORM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | | 1 / Z3 | | | |
| CIPS=CTB*Z4/Z2 | | | | 17.550 | | | |
| CRC1 =CTB X R | | | | 0.0 | | | |
| PRE-IOC CRC1 =CRC1 X Z6 | | | | 0.0 | | | |
| POST-IOC CRC1 =CRC1 X (1.0-Z6) | | | | 0.0 | | | |
| COEM =UEM OR CTR*Z5/Z2/ENVR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND OCM WERE | | | | 0.0 | 15.000000 | 0.0 | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.4.4.2 CONTROL ELECTRONICS

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|----------|------|--------------|--------------------|-----------|-----|-----|
| T= | 1.000000 | TF= | 1.000000 | CDCER= | 0.0 | | |
| M= | 1.000000 | LEM= | 0.0 | CDEXP= | 0.0 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 70.199997 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.0 | Z3= | 60.000000 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 60.000000 | Z5= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | SET | SUM TO 1.4.4 | 8, MILLIONS | | | |
| CD=CDCER X (T X DF)XX(CDEXP) X CF | | | | 0.0 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 70.200 | | | |
| ORM =T / M | | | | 1.000 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 1.000 | | | |
| CTFU=(CLRM / E)X((ORM X Z1+.5)XX(E) -0.5XX(E)) | | | | 70.200 | | | |
| CTB =(1CLRM/E)X((ORM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | | 70.200 | | | |
| CIPS=CTB*Z4/Z2 | | | | 70.200 | | | |
| CRCI =CTB X R | | | | 0.0 | | | |
| PRE-IOC CRCI =CRCI X Z6 | | | | 0.0 | | | |
| POST-IOC CRCI =CRCI X (1.0-Z6) | | | | 0.0 | | | |
| COEM =OEM OR CTB*Z5/Z2/ENYR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CULER, CICER, AND OEM WERE | | | | 0.0 | 60.000000 | 0.0 | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980

TABLE 1.4.4.3 CONTROL LOTLE

INPUT PARAMETERS

INPUT COEFFICIENTS

| | | | | | |
|------|----------|------|-----------|--------|-----------|
| T= | 1.000000 | TF= | 1.000000 | CDCER= | 11.700001 |
| M= | 1.000000 | LEM= | 0.0 | CDEXP= | 1.000000 |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.0 |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 0.0 |
| R= | 0.0 | Z3= | 60.000000 | BYEAR= | 1979 |
| DF= | 1.000000 | Z4= | 60.000000 | Z5= | 0.0 |
| | | | | Z6= | 0.0 |

CALCULATED VALUES

SET

SUM TO 1.4.4

\$, MILLIONS

CD=CDCER X (T X DF)XX(CDEXP) X CF 11.700

CLRM=CICER X (M)XX(CIEXP) X CF X TF 0.0

1.3.3 IORM = T / M 1.000

E = 1.0 + LOG(PHI) / LOG(2.0) 1.000

CIFU=(CLRM / E)X(IORM X Z1+0.5)XX(E) -0.5XX(E) 0.0

CTB = ((CLRM/E)X(IORM X Z3 + 0.5)XX(E) -0.5XX(E))) / Z3 0.0

CIPS=CTB*Z4/Z2 0.0

CRCI =CTB X R 0.0

PRE-10C CRCI =CRL1 X Z6 0.0

POST-10C CRCI =CRCI X (1.0-Z6) 0.0

COEM =OEM OR CTB*Z5/Z2/ENYR 0.0

COMMENTS

1977 DATA ENTERED FOR CDCER, CICER, AND OEM WERE 10.000000 0.0 0.0

1.4.5 GRID INTERFACE

This element includes power conversion equipment that receives electrical power from the power collection system and conditions/converts it to a high voltage dc or ac power acceptable for input into the national power grid.

Converter stations accept 40 kV dc power and output 500 kV ac or dc. The concept utilizes a solid-state inversion/step-up concept typified by an existing dc - ac conversion station located in Sylmar, California. Although specific design details of this system await clarification in a future study effort, an analysis and cost estimate was prepared as shown in Table 1.4-9.

Table 1.4-9. Grid Interface (WBS 1.4.5)

| ITEM DESCRIPTION | SPECIFICATION | GRS QUANTITY | PROJECTED UNIT COST | TOTAL (1979 \$) |
|----------------------------------|---------------------------------|--------------|------------------------|---------------------------|
| CONVERTER STATIONS | 400 mW 500 kV ac or kV dc | 12 EA. | \$11.7×10 ⁶ | \$140.389×10 ⁶ |
| ISOLATION SWITCH-GEAR | 4×4×4 m | 36 EA | \$468,000 EA | \$16.848×10 ⁶ |
| FILTER YARDS | | 12 | \$117,000 EA | \$1.404×10 ⁶ |
| INTERCONNECT TOWERS & FOUNDATION | 500 kV ac TOWERS | 90 EA | \$165,600 EA | \$14.904×10 ⁶ |
| INTERCONNECT TRANSMISSION CABLE | 12 LINES | 120 MILES | \$105,300/MI | \$12.636×10 ⁶ |
| TOTAL/GRS | | | | \$186.151×10 ⁶ |

The CER for grid interface DDT&E was derived from cost estimates in the "Technical Study Report on Pacific Northwest-Southwest dc Inter-tie," prepared by the Bonneville Power Administration in February, 1976. This DDT&E estimate was based on six cost quotations which Bonneville received on a 1.44 GW and a 2.20 GW inter-tie. The total cost for the 1.44 GW terminal (\$156.7 M) was allocated as 30% DDT&E and 70% ICI. This judgment was based on the assumption that most of the facility will be a standard design.

Cost estimates are presented in Table 1.4.5.1 on electrical equipment and in Table 1.4.5.2 on DDT&E.

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.4.5.1 ELECTRICAL EQUIPMENT

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|---|----------|------|--------------|--------------------|------------|---------|----------|
| T= | 1.000000 | TF= | 1.000000 | CDCER= | 0.0 | | |
| M= | 1.000000 | OEM= | 0.0 | CDEXP= | 0.0 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 186.180939 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 1.000000 | | |
| R= | 0.0 | Z3= | 60.000000 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 60.000000 | Z5= | 0.0 | Z6= | 1.000000 |
| CALCULATED VALUES | | SET | SUM TO 1.4.5 | \$,MILLIONS | | | |
| CD=CDCER X (T X DF)XX(CDEXP) X CF | | | | 0.0 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 186.181 | | | |
| ORM =T / M | | | | 1.000 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 1.000 | | | |
| CTFU=(CLRM / E)X((ORM X Z1+.5)XX(E) -0.5XX(E)) | | | | 186.181 | | | |
| CTB =((CLRM/E)X((ORM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | |) / Z3 | | 186.181 | |
| CIPS=CTB*Z4/Z2 | | | | 186.181 | | | |
| CRCI =CTB X R | | | | 0.0 | | | |
| PRE-IOC CRCI =CRCI X Z6 | | | | 0.0 | | | |
| POST-IOC CRCI =CRCI X (1.0-Z6) | | | | 0.0 | | | |
| COEM =OEM OR CTB*Z5/Z2/ENYR | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND OEM WERE 0.0 159.128998 0.0 | | | | | | | |
| COSTS BASED ON ITEMIZED REQUIREMENTS FOR ROCKWELL DESIGN. 12 CONVERTERS | | | | | | | |
| STATIONS, 36 ISOLATION SWITCH GEAR, 12 FILTER YARDS, 90 INTERCONNECT | | | | | | | |
| TOWERS/FOUNDATIONS, AND INTERCONNECT TRANSMISSION CABLE. | | | | | | | |

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.4.5.2 GRID INTERFACE-DOTCE

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|---|----------|------|--------------|--------------------|-----------|-----|-----|
| T= | 5.000000 | TF= | 1.000000 | CDCER= | 44.126541 | | |
| M= | 1.000000 | UEM= | 0.0 | CDEXP= | 0.604000 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.0 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 0.0 | | |
| R= | 0.0 | Z3= | 60.000000 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 60.000000 | Z5= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | GM | SUM TO 1.4.5 | \$,MILLIONS | | | |
| CD=CDCER X (T X DF)XX(CDEXP) X CF | | | | 116.648 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 0.0 | | | |
| EVR1 =T / M | | | | 5.000 | | | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | 1.000 | | | |
| CTFU=(CLRM / E)X((EVR1 X Z1+.5)XX(E) -0.5XX(E)) | | | | 0.0 | | | |
| CTB =((CLRM/E)X((EVR1 X Z3 + 0.5)XX(E) -0.5XX(E)) | | | | 1 / Z3 | | | |
| CIPS=CTB*Z4/Z2 | | | | 0.0 | | | |
| CRC1 =CTB X R | | | | 0.0 | | | |
| PRE-10C CRC1 =CRC1 X Z6 | | | | 0.0 | | | |
| POST-10C LRC1 =CRC1 X (1.0-Z6) | | | | 0.0 | | | |
| CUEM =UEM OR CTB*Z5/Z2/EVR1 | | | | 0.0 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER,CICER, AND UEM WERE 37.714996 0.0 0.0 | | | | | | | |
| CDCER/CDEXP BASED ON MSFC 1977 UTILITY INTERFACE INFORMATION. | | | | | | | |

1.4.6 OPERATIONS

This element includes the planning, development, and conduct of operations at the ground receiving station. It covers both direct and support personnel and expendable maintenance supplies required for ground station operation and maintenance.

Operations and maintenance personnel required after IOC are identified as a 300 personnel staff to provide a 24-hour operation, maintenance/repair, security, and administrative support (Table 1.4-10). A cost estimate for maintenance material (expendables, trucks, and equipment); standby auxiliary power; and test/support equipment is also identified in the table.

Table 1.4-10. Operations Requirements

| ITEM | SHIFT | NO. | TOTAL | 1979 DOLLARS |
|--|-------------|----------------|------------|--------------------------|
| • OPERATIONS & MAINTENANCE PERSONNEL | | | | |
| COMMAND & CONTROL CENTER (PERSONNEL + SUPERVISORY) | 1 2 3 | 30 30 20 | 80 | |
| CONVERTER STATION (TOTAL FOR 12 STATIONS) | 1 2 3 | 36 36 36 | 108 | |
| 24-HOUR MAINTENANCE, REPAIR, SECURITY, & G&A/SUPPORT | | 112 | 112 | |
| | | | <u>300</u> | |
| • MAINTENANCE MATERIAL | | | | |
| EXPENDABLES, TRUCKS, EQUIP., UTILITIES, TEST/SUPPORT EQUIP. | | | | \$15.362×10 ⁶ |

Cost estimates are shown in Table 1.4.6.1 for operations and maintenance personnel and in Table 1.4.6.2 for maintenance material.

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.4.6.1 OPER. & MAINT. PERSONNEL

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|------------|----------|-----------|--------------------|-----|--------------|-----|
| T= | 300.000000 | TF= | 1.000000 | CDCER= | 0.0 | | |
| M= | 300.000000 | UEM= | 16.199997 | CDEXP= | 0.0 | | |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.0 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 0.0 | | |
| R= | 0.0 | Z3= | 60.000000 | BYEAR= | | 1979 | |
| DF= | 1.000000 | Z4= | 60.000000 | Z5= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | PEUP/DAY | | SUM TO 1.4.6 | | \$, MILLIONS | |
| CD=CDCER X (T X DF)XX(CDEXP) X CF | | | | 0.0 | | | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | 0.0 | | | |
| E = T / M | | | | 1.000 | | | |
| E = 1.0 + LOG(PHI) / LOG(2.0) | | | | 1.000 | | | |
| CTFU=(CLRM / E)X((ORM X Z1+0.5)XX(E) -0.5XX(E)) | | | | 0.0 | | | |
| CTB =((CLRM/E)X((ORM X Z3 + 0.5)XX(E) -0.5XX(E)) | | | |) / Z3 | | 0.0 | |
| CIPS=CTB*Z4/Z2 | | | | 0.0 | | | |
| CRC1 =CTB X R | | | | 0.0 | | | |
| PRE-IOC CRC1 =CRC1 X Z6 | | | | 0.0 | | | |
| POST-IOC CRC1 =CRC1 X (1.0-Z6) | | | | 0.0 | | | |
| UEM =UEM OR CTB*Z5/Z2/ENR | | | | 16.200 | | | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND UEM WERE | | | | 0.0 | 0.0 | 13.046150 | |
| 3 SHIFTS/DAY. 360 DAYS/YEAR. 300 PERSONS/DAY. \$150/PERSON | | | | | | | |

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ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
TABLE 1.4.6.2 MAIN1. MATERIAL

INPUT PARAMETERS

INPUT COEFFICIENTS

| | | | | | |
|------|----------|------|-----------|--------|------|
| T= | 1.000000 | TF= | 1.000000 | CDCER= | 0.0 |
| M= | 1.000000 | UEM= | 15.362101 | CDEXP= | 0.0 |
| CF= | 1.000000 | Z1= | 1.000000 | CICER= | 0.0 |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 0.0 |
| R= | 0.0 | Z3= | 60.000000 | BVEAR= | 1979 |
| DF= | 1.000000 | Z4= | 60.000000 | Z5= | 0.0 |
| | | | | Z6= | 0.0 |

CALCULATED VALUES

SET

SUM TO 1.4.6

\$, MILLIONS

CD=CDCER X (T X DF)XX(CDEXP) X CF 0.0

CLRM=CICER X (M)XX(CIEXP) X CF X TF 0.0

ORM = T / M 1.000

E = 1.0 + LOG(PHI) / LOG(2.0) 1.000

CTFU=(CLRM / E)X((ORM X Z1+0.5)XX(E) -0.5XX(E)) 0.0

CTB = ((CLRM/E)X((ORM X Z3 + 0.5)XX(E) -0.5XX(E))) / Z3 0.0

CIPS=CTB*Z4/Z2 0.0

CRC1 =CTB X R 0.0

PRE-IOC CRC1 =CRC1 X Z6 0.0

PUST-IOC CRC1 =CRC1 X (1.0-Z6) 0.0

UEM =UEM OR CTB*Z5/Z2/ENR 15.362

COMMENTS

1977 DATA ENTERED FOR CDCER, CICER, AND UEM WERE 0.0 0.0 13.130000

1.5 MANAGEMENT AND INTEGRATION

This element includes all efforts and material required for management and integration functions at the systems level and program level. It encompasses the following functions:

1. Program Administration
2. Program Planning and Control
3. Contracts Administration
4. Engineering Management
5. Manufacturing Management
6. Support Management
7. Quality Assurance Management
8. Configuration Management
9. Data Management
10. Systems Engineering and Integration

This element sums all direct effort required to provide management control including planning, organizing, directing, and coordinating the project to ensure that overall project objectives are accomplished. These efforts overlay functional work areas (e.g., engineering, manufacturing, etc.) and assure that they are properly integrated at higher levels. Also included are those efforts required in the coordination, gathering, and dissemination of management information, plus engineering efforts related to the establishment and maintenance of a technical baseline for a system by generation of system configuration parameters, criteria, and requirements. This includes requirements analysis and integration, system definition, system test definition, interfaces, safety, reliability, and maintainability. Efforts required to monitor system development and operations are part of this element to ensure that designs conform to the baseline specifications.

The management and integration function for DDT&E TFU, ICI, RCI and O&M are estimated at a cost equal to 5% of the corresponding total dollar estimates for WBS elements of the satellite (1.1), space construction and support (1.2), transportation (1.3), and the ground receiving station (1.4).

Cost estimates for management and integration charges are presented in Table 1.5 for the Rockwell reference SPS configuration.

TABLE 1.5 ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
MANAGEMENT AND INTEGRATION

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|--|----------|----------|-----------|--------------------|------|-------------|-----|
| T= | 0.0 | TF= | 1.000000 | CDCER= | 0.0 | | |
| M= | 0.0 | UEM= | 0.0 | CDEXP= | 0.0 | | |
| CF= | 0.0 | Z1= | 1.000000 | CICER= | 0.0 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 0.0 | | |
| R= | 0.0 | Z3= | 60.000000 | BYEAR= | 1979 | | |
| DF= | 1.000000 | Z4= | 60.000000 | Z5= | 0.0 | Z6= | 0.0 |
| CALCULATED VALUES | | 5% * ALL | | SUM TO | | 1 | |
| | | | | | | 8, MILLIONS | |
| CD=CDCER X (T X DF)XX(CDEXP) X CF | | | | | | 1482.630 | |
| CLRM=CICER X (M)XX(CIEXP) X CF X TF | | | | | | 0.0 | |
| ORM =T / M | | | | | | 0.0 | |
| E =1.0 + LOG(PHI) / LOG(2.0) | | | | | | 0.0 | |
| CTFU=(CLRM / E)X(ORM X (1+.5)XX(E) -0.5XX(E)) | | | | | | 2407.669 | |
| CTB =((CLRM/E)X(ORM X (Z3 + 0.5)XX(E) -0.5XX(E)) | | | | 1 / Z3 | | 0.0 | |
| CIPS=CTB*Z4/Z2 | | | | | | 569.734 | |
| CRC1 =CTB X R | | | | | | 6.567 | |
| PRE-IDC CRC1 =CRC1 X Z6 | | | | | | 3.395 | |
| POST-IDC CRC1 =CRC1 X (1.0-Z6) | | | | | | 3.172 | |
| UEM =UEM OR (CTB*Z5/Z2/ENVR | | | | | | 3.535 | |
| COMMENTS | | | | | | | |
| 1977 DATA ENTERED FOR CDCER, CICER, AND UEM WERE | | | | 0.0 | 0.0 | 0.0 | |
| DOTS,TFU,ICI,ICI, AND UEM ARE | | | | | | | |
| CALCULATED AT 5% OF CORRESPONDING TOTALS | | | | | | | |
| FOR NBS 1.1 THROUGH 1.4 | | | | | | | |

1.6 MASS CONTINGENCY

A cost contingency has been added to the SPS Program to provide for a 25% mass contingency due to the potential increased weight as a result of design/development activities that would affect the procurement of systems during any phase of the program. This allowance is costed as a 15% bottom line contingency to the DDT&E, TFU, ICI, RCI and O&M elements of the program. Table 1.6 presents the amounts in each of these areas based on the totals of space segment WBS line Items 1.1 - Satellite, and 1.2 - Space Construction and Support for the Rockwell Reference SPS Configuration. Space Transportation (WBS 1.3) was not included in these calculations as fleet sizes and number of flights were established on the basis of masses to orbit with a 25% contingency.

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TABLE 1.6 ROCKWELL SPS CR-2 REFERENCE CONFIGURATION, 1980
MASS CONTINGENCY

| INPUT PARAMETERS | | | | INPUT COEFFICIENTS | | | |
|------------------|----------|------|-----------|--------------------|-----|------|-----|
| T= | 0.0 | TF= | 1.000000 | CDCER= | 0.0 | | |
| M= | 0.0 | DEM= | 0.0 | CDEXP= | 0.0 | | |
| CF= | 0.0 | Z1= | 1.000000 | CICER= | 0.0 | | |
| PHI= | 1.000000 | Z2= | 60.000000 | CIEXP= | 0.0 | | |
| R= | 0.0 | Z3= | 60.000000 | BYEAR= | | 1979 | |
| DF= | 1.000000 | Z4= | 60.000000 | 25= | 0.0 | Z6= | 0.0 |

CALCULATED VALUES

SUM TO 1

\$, MILLIONS

CD=CDCER X (T X DF)XX(CDEXP) X CF 2454.463

CLRM=CICER X (M)XX(CIEXP) X CF X TF 0.0

ERM = T / M 0.0

E = 1.0 + LOG(PHI) / LOG(2.0) 0.0

CTFU=(CLRM / E)X((ERM X Z1+.5)XX(E) -0.5XX(E)) 3085.372

CTB =((CLRM/E)X((ERM X Z3 + 0.5)XX(E) -0.5XX(E))) / Z3 0.0

CIPS=CTB*Z4/Z2 778.208

CRCI =CTB X R 7.874

PRE-IOC CRCI =CRCI X Z6 0.650

POST-IOC CRCI =CRCI X (1.0-Z6) 7.224

DEM =DEM OR (IP*25/22/ENYR 3.009

COMMENTS

1977 DATA ENTERED FOR CDCER, CICER, AND DEM WERE 0.0 0.0 0.0
A 25% MASS CONTINGENCY IS CUSTED AS A 15% COST CONTINGENCY ON 1.1, 1.2,
TRANSPORTATION CALCULATIONS (WBS 1.3) FOR FLEET AND NUMBERS OF FLIGHTS
ARE BASED ON MASSES WITH A 25% CONTINGENCY.

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TECHNICAL REPORT STANDARD TITLE PAGE

| | | | | | |
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| 16. ABSTRACT <p>Present electrical energy usages indicate the need for new, nondepletable energy sources and advanced energy conversion systems in the near future. The Satellite Power System (SPS) concept addresses this requirement, and completed studies have attested to the technical feasibility of power stations located in space and to the potentially economic advantages as compared with candidate earth-based energy systems in the calendar period 2000-2030. This volume documents cost and programmatic aspects of a recommended SPS reference concept based on the results of several contracts with NASA and independent company-sponsored activities by the Space Operations and Satellite Systems Division of Rockwell International.</p> <p>The results of prior studies performed by Rockwell International under this contract have been documented in Rockwell document SSD 79-0010.</p> <p>This volume has been released in two segments because of the large bulk of material available. The first report, identified as Volume VI-1, "Cost and Programmatic," presents a summary of the cost data reviewed as well as providing conclusions and recommendations. The second segment, identified as Volume VI-2, "Cost and Programmatic Appendix," contains the detailed computer runs structured in an agreed-to Work Breakdown Structure (WBS) format plus computer-generated summaries. Both volumes contain very brief summaries of the six configurations developed during the Exhibit D study period.</p> | | | | | |
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